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DAIRYING ON SECOND CLASS LAND. AN EXAMINATION OF CHANGES IN FARMING SYSTEMS.

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and

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As a result of the recent low prices of butter and developing facilities for milk transport a number of farmers in districts hitherto producing butter and store stock are now tempted to turn to the sale of milk. Domestic objections to the trouble of making butter combine with low returns to make the womenfolk of the farms favour the change. There is scarcely any doubt that direct sale of milk has proved to be one of the most profitable farm enterprises during recent years, especially where the bulk of the supply could be sold at " liquid " price, and where pastures were fairly good. In the newly-opened collection areas, however, the price tends rather to the level of the " surplus ", and in some the main object of the dealers is that of purchasing milk for manufacturing purposes. On the whole the land of these districts tends to be poorer than in those previously opened up for milk production.

The products of the dual purpose stock-raising herds have been store-cattle, prime draft cows, and butter; with pigs of one type or another as at least a partial by-product. The combination of pastured stock on these farms has included the dairy herd, store cattle from the weaning stage to 2—2½ years old, and usually a permanent flock of sheep. On the farms with some good pastures fat lambs and on others with poorer pastures stores have been produced. The sales from farms of two fairly typical areas of this kind; one with second-class rising to slightly better land, and the other with second-class tending to lower quality; indicate the proportions of receipts from each class of stock. Deducting purchases of livestock of each class, the livestock output is shown.

While the general character of the combination of enterprises on these two groups of farms is seen to be much the same some quite significant differences can be discerned in the higher sales of milk and butter, the lower sales of sheep, and the higher sales of pigs from the better-land farms. The lower

sales of horses, and the higher sales of poultry and eggs are also significant in their own way. The sales of cattle do not show much difference, but there are differences in the types and quality of cattle sold. Other differences will be discussed at a later stage.

District A. Better land.

	Per 100 acres. Total Sales.	Per cent.	Gross Output.	Per cent.
	£ s. d.		£ s. d.	
Horses ...	5 16 5	1.3	14 5 9*	3.4
Cattle ...	114 18 8	24.8	97 10 5	22.9
Butter and milk ...	88 5 11	19.1	88 5 11	20.7
Sheep ...	43 0 1	9.3	29 7 2	6.9
Pigs ...	88 2 4	19.0	70 16 2	16.6
Main livestock ...	340 3 0	73.5	310 5 5	70.5
Poultry and eggs ...	88 1 10	19.0	93 9 10*	22.0
Others ...	34 14 6	7.5	32 0 9	7.5
Total ...	463 0 4	100.0	425 16 0	100.0

Including increase in inventory valuations.

District B. Poorer land.

	Per 100 acres. Total Sales.	Per cent.	Gross Output.	Per cent.
	£ s. d.		£ s. d.	
Horses ...	20 9 4	5.2	8 4 6	2.6
Cattle ...	128 10 10	32.5	97 8 1	31.2
Butter and milk ...	48 13 7	12.3	48 13 7	15.6
Sheep ...	72 9 8	18.3	40 11 1	12.9
Pigs ...	26 18 1	7.8	21 18 8	7.0
Main livestock ...	299 1 6	75.6	216 15 11	69.3
Poultry and eggs ...	53 11 8	13.5	55 0 9	17.7
Others ...	43 6 5	10.9	40 15 0	13.0
Total ...	395 19 7	100.0	312 11 8	100.0

"Gross output" equals sales plus or minus valuation differences, and minus purchases of livestock.

It would be possible to set out conditions which would show a far greater contrast to those of District B. and from the best pasture districts of Wales an illustration of farms with very much higher sales of milk could be obtained. But this illustration of District A. has been chosen because it indicates the

conditions to which District B. will approximate when the change towards more milk production has occurred. A comparison of conditions in District B. with a district with still better land and pasturage than the present District A. would be to a considerable extent unreal and unpractical. But the conditions in District A. may be compared with those of a district slightly better than its own.

The combinations of livestock pastured and kept naturally vary from farm to farm, but also they vary to some extent from district to district. In the two areas quoted the number of livestock per 100 acres were :

	District A.	*District B.*
Horses (working and other) ...	5	7
Cows ...	12	10
Other cattle ...	25	23
Sheep ...	41	95
Pigs ...	56	16
Poultry ...	282	164
Stock units (cows) ...	40.3	38.4

The importance of these combinations especially of cattle and sheep is in the full utilisation of all the pasturage. The cows and the younger store cattle obtain the better summer pasturage, while the stronger store cattle get the poorer and also follow the cows and younger stores, while the sheep usually get the poorer summer pastures and follow the stronger store cattle or the cows. During the winter the sheep tend to get access to most or all of the pastures.

Although the general stocking appears much the same in each district when it is measured in stock-units, there is an appreciable difference. And there is a very considerable

	Land utilisation (per 100 acres).			
	District A.		*District B.*	
	Acres.	*Yield Tons.*	*Acres.*	*Yield Tons.*
Cereals ...	18.9	10.5	14.0	6.7
Roots ...	2.0	23.7	2.6	24.0
Potatoes ...	1.7	11.0	1.7	8.5
Hay ...	18.3	16.4	25.2	18.9
Pasture ...	59.1	—	56.5	—
Purchased foods (per 100 acres) ...	£74 12 1		£65 7 8	
Artificial manures (per 100 acres) ...	£10 2 4		£7 2 2	

difference between the groups in the requirement of concentrated feed. The stock combination of District A. has an appreciably higher requirement of these feeds. There is much more of actual feeding by pasturage of stock in District B. than in District A. The stock combination in each district has been closely related to the quality and capacity of the land.

It is difficult to display the exact differences between the stock on the farms in these different districts and between their feed requirements. The difference in quantity of stock may be set at about ten per cent. higher in District A. than in District B, but the supply and requirement of grain and concentrated feed is about 33 per cent. higher. The total supply of roots is about equal, but the hay supply and requirement is slightly higher on the poorer land farms but this is fully balanced by use of extra oat-straw on the better-land farms. While the difference in quantity of fertilisers used does not appear very great in itself there can not be any doubt that the higher supply together with the greater amount of residual manurial values of grain and feedingstuffs have an appreciable effect on the feed yield of pastures. These difference and those in the quality of pasturage due to general differences in soils are reflected in the *sales* and the *gross output* of the two districts.

Total.		*Sales.*	*Gross Output.*
Poorer-land	...	100	100
Better-land	...	117	136
Main-Livestock Classes.			
Poorer-land	...	100	100
Better-land	...	113	143

While the proportionate difference in sales is not great, there is on the whole more buying-in to maintain the sales from the poorer-land farms, and there is a very considerable difference between the output in favour of the better land farms. The value of the output may be regarded as the product of the land and the feedstuffs used. On the whole, the products of the better-land farms are more of the nature of final products than those of the poorer-land farms.

The positions of farmers in these two districts in respect of change towards more dairying and to milk-selling vary to a considerable extent. It is suggested that in District B. with second-class tending to poorer land, the practical possibilities of change are in the direction of the combinations found in District A. There is very considerable risk in a change towards

milk-selling in such a district except under quite special circumstances. On the other hand, efforts will be made to develop and extend the dairy herds of District B. and to sell milk; and this may be possible.

In District B. there is a possibility of intensification of production by improving pastures and hay crops, and by using more concentrated feeds. This intensification may be in the form of more stock of each of the types now carried, but is more likely to take the form of increases in some classes and types and decreases in others and of some changes towards improvement of the qualities of stock. But as there is interest in the possibilities of selling milk in District B. it is necessary to consider some of the conditions of the possible change.

Hitherto the milking herd, butter-making and raising of yearlings, have been essentially joint enterprises. The separated milk has been regarded as essential to rearing good quality yearlings. But in the full utilisation of the pastures the sheep enterprise also has been of somewhat of a joint character.

The essential problem before those farmers in District B. who are considering the change to selling milk is that of securing revenue (making net sales) at least equal to those under the previous system with equal or lower expenditure, or that of securing higher sales with not more than proportionate or with lower than proportionate expenditure.

With loss of the supply of separated milk when milk is sold instead of butter, the probability is that fewer calves will be reared, and consequently sales of store cattle will be smaller. Perhaps this is not a necessary consequence, for methods of calf-rearing other than by the use of separated milk may be used and made successful but hitherto it has been commonly, almost universally, affirmed that use of this milk was necessary. And the general experience is that sale of milk leads to less rearing of calves. With such smaller sales of store cattle, and with more pasturage for cows, the tendency will be to increase the size of the milking herd both to secure revenue and to use pastures. But, as indicated, the pasturages on the individual farms vary in quality, and the question arises whether there is sufficient of good pasturage for an increased number of cows. Hitherto, on most farms except those few producing fat lambs, cows, weaned calves and yearlings, have been kept practically up to the carrying capacity of the better land. In such cases there will be restricted possibilities of increasing the milking herd except at increased cost. With a reduction in store cattle,

especially of the stronger type, the alternative then is an increase in the sheep flock. In this case the practical question is whether the use of pasture under a slightly greater herd of cows, less store cattle, and more sheep will be as complete and economical as formerly.

Should calves continue to be reared in the former numbers, any increase in milking cows is dependent on reduction in numbers of older store cattle or in sheep, and again the question of full use of pasturage arises. Some improvement of pasturage with increase in carrying capacity either for more milking cows or for general stock is quite possible, but it will not be universal.

Other aspects of the economy of the former combinations of livestock in the use of pastures are found in hay supplies and some arable cropping. The oat crop has provided some fodder for store cattle, and the rotational cultivation has maintained quality in pasturage and more particularly in hay. With a reduction in numbers of store cattle there may be a tendency towards less arable and consequently to smaller areas of the better hay supplies. With an increase in the milking herd greater supplies of the higher quality hay will be required, and necessity for purchase of more concentrated feed will follow any reduction in arable. The supply of good hay and need of concentrated feedstuffs, in fact, are likely to prove important factors in the success of change from stock rearing to milk selling. With increase in the milking herd, in fact, the indications are that an increase rather than a decrease in arable would be required, but judging by general experience this it not very likely to occur. The change towards more dairying on this type of land cannot be made effective without improvement of pastures.

Briefly, the whole economy of the farms on the second class land will be altered by a change to sale of liquid milk which is followed by an increase in the number of milking cows, and these two changes usually go together. One is almost certain to make the other necessary to the maintenance or possible increase of revenue. Such changes as are under consideration have been made in other parts of Wales in former periods, but on the whole on better and less exposed lands, with somewhat longer pasturage seasons. The former changes do not provide a complete or equal comparison with those now proceeding.

Another important consideration in respect of the herds whose purpose may be changed is that the greater part of the milk supply has been obtained during nine months of the year —March to November (and in some herds between April and

October) although some individual farmers have increased winter milk-yield for making butter. A continuation of this general trend of seasonal production will bring the consequence of low average price for milk. On the other hand, change over to more winter production may involve some purchase of cows, and when it is made will certainly involve heavier purchases of concentrated feed.

On this class of land it will still be necessary to maintain a herd of cows with good constitutions and generally " hardy " in character. In any change towards more dairying there may be a tendency to seek for " milking " strains and this may be done given that the heavier milking cows have good conformation and constitution. There is some risk that in making a change towards more dairying and changing the type of cows there may be some reduction in selling quality of store cattle, more particularly steers, but this need not occur; and with good foundation stock and better pasturage and feeding there may be improvement.

In the case of District A. with second-class tending to better land the general considerations are very much the same as in that of District B. except that here the possibilities of economic change are somewhat higher. Here specialisation towards dairying and especially milk-selling may be quite definite. But again, the economic possibilities of increasing the herd of cows largely depend on the extent of the relatively good pastures capable of carrying cows; or the possibilities of improving pastures and also of improving meadows or obtaining leys to make good hay. Here, judging by experience, there is likelihood of tendency to reduce arable but this is not necessary and may be inadvisable. And again in this case there will be some change in the stocking. As the size of the milking herd increases there will be a reduction in the *proportionate* numbers of other stock, possibly some absolute reduction. Stated in another way, as pastures are improved and the stock carrying capacity of the farms is increased by this and the purchase of more feedstuffs the increased capacity is taken up by the dairy herd. Conditions will vary, and in some cases the milking herd will be increased at the expense of other stock; while in others the reduction in other classes of stock may not be very great. On this class of land it is scarcely possible to make full or economical use of all the pastures, even after considerable improvement, without the aid of stock other than cows. Having set out the general considerations it is necessary to try to illustrate the process and the effect of change.

In the re-organization of the farm the most significant change in stocking would be the increase in the number of dairy cows by anything from 50—100 per cent. Some rearing could be done but most probably this would be confined to the rearing of the best heifer calves for the replenishment of the herd. The rearing could be done during the summer months when there is the more plentiful supply of milk which could only be disposed of at a low price. Again, there is no great disadvantage in summer rearing of calves for the herd as is the case for the store stock market, whereas for that purpose autumn and winter calves are always to be desired.

Whether or not sheep can be maintained in equal numbers after the change will depend primarily upon the individual farm; if there is a considerable acreage of rough-grazing, considerable reduction need not occur. Generally, however, sheep management would be changed. Instead of maintaining the largest possible permanent flock throughout the year, the ewe-flock will almost certainly be reduced and there will be a tendency to buy flying flocks in the autumn; these would follow the dairy cows over the pastures and in this way they would dovetail into the new system.

Milk production would be a more specialised system and receipts from milk would provide the main part of the farm income. Cattle sales would consist mainly of draft cows and calves, store cattle production (if kept on) would become quite a subsidiary enterprise as the dairy cows would need all the best pastures and also the best of the home-grown foods. Again the sheep would be a complementary enterprise and this branch would not be looked upon in quite the same way as a separate productive branch of the farm.

On most farms some additional labour would probably be necessary, partly for special purposes like drainage and other extra work on pastures. There would also be some change in the nature of the work. More specialisation would be called for and a fuller understanding of feeding and attention of the dairy herd. As effective and economical feeding of cows would become an important item in determination of profit or loss the combination of home-grown food with purchased feeds would need careful study. Again, with any increase in labour supply, the full utilisation of labour might depend to a large degree on the extent to which the use of home-grown foods would qualify the necessity of considerably larger expenditure on concentrates. However, higher costs in feed requirements would be necessary in order to improve the quality of the rations fed. As some

pastures would need improvement higher expenditure on manures would be necessary and justified, especially for top dressings. The increased use of concentrates would assist attainment of this end to some small degree, but the proper conservation of the manure would become very important as it would be stored in the farm yard and is there subject to serious loss.

The financial and other conditions most closely approaching those which might be possible in District A. (when considerable improvement in pastures has been made) which have been found in actual farm accounts are illustrated below, where the average conditions on a group of milk farms are compared with those recently existing in District A.

In this comparison it should be noted that the land in farms of District A. is somewhat poorer than that of the milking farms, as indicated by difference in rental value between 18s. 3d. and 24s. 6d. per acre, or by the difference in stock units (in cows) carried between 40 and 54 per 100 acres. It is difficult to obtain an exact assessment of differences in quality of land, but the difference here may be of the order of 25 to 30 per cent. Whether it is possible to obtain an improvement of this order in the pastures and meadows of farms in District A. depends largely upon conditions of individual farms. It may not be impossible on some farms but will certainly be difficult

Comparative figures of stocking, sales and expenses of milk selling and butter farms.

Stock carried per 100 acres.

		Milk. No.	*Butter (District A).* No.
Horses	...	5	5
Dairy cows	...	20	12
Two-year-olds	...	4	3
Yearlings	...	8	10
Calves	...	19	12
Breeding ewes	...	30	17
Other sheep	...	34	24
Breeding sows	...	5	3
Other pigs	...	69	53
Poultry	...	230	282
Stock units (cows)	...	54	40

and too expensive on others. Again it may be noticed that there is generally greater intensity of stocking on the milking farms. If these differences are held in view the comparison may be presented.

As this comparison has been obtained by actual accounting it necessarily follows that the results partly arise from recent

prices of produce—namely for the year 1930-1; and that any such comparisons are subject *inter alia* to changes in prices of one, or more, or of all the products. But the most important

Sales per 100 acres.	*Milk.*	*Butter.*
	£ s. d.	£ s. d.
Horses ...	15 8 2	5 16 5
Cattle ...	135 10 0	114 18 3
Dairy produce ...	465 3 6	88 5 11
Sheep and wool ...	53 0 10	43 0 1
Pigs ...	71 12 7	88 2 4
Poultry and eggs ...	61 12 5	88 1 10
Others ...	64 3 9	34 14 6
Total ...	866 11 3	463 0 4

Expenses per 100 acres.	*Milk.*	*Butter.*
	£ s. d.	£ s. d.
Rent and rates ...	123 18 3	91 17 3
Labour (including wages of sons and daughters)	191 13 11	126 9 0
Purchased foods ...	174 14 4	74 12 1
Fertilisers ...	14 6 10	10 2 4
Livestock ...	65 7 8	13 12 9
Others ...	75 2 0	48 14 7
Total ...	648 3 0	365 8 0

Margin on Milk farm = £218 8s. 3d. Margin on Butter farm = £97 12s. 4d.

fact, probably, is that the price of milk was about 11d. per gallon. A fall of 2d. per gallon would reduce profits on the milk farms by about £85 (to about £133). The high number of calves on the milking farms should be observed. It should also be noted that the " profits " here shown do not include all the farmer's or the family's earnings per 100 acres, because a certain amount of such income may be included in the item of " wages ".

Thus if it were possible to improve pasturages, &c., of

District A. to raise the stock carrying capacity by about 30 per cent., and there was a very large increase in purchase and use of feedstuffs, it might be possible to raise the sales to the standard of the milking farms. The total expenses and the profits might possibly be somewhat similar to those of the milking farms, but they would be differently distributed. There would not be an increase in rent, but there cannot be any doubt that £82 difference in rents would be absorbed in proportionately greater increases in other items of expenditure—drainage and other labour on improvement of pastures, seeds and fertilisers, in feedstuffs, and possibly in livestock.

This might be the position on the farms of District A. with the greatest possibilities of improvement. But intermediate positions must be considered, partly because they would represent the intermediate conditions in the process of making the change on the better farms, and also because they might represent the final positions on farms with lower possibilities of improvement.

The possible intermediate positions may be illustrated as below :

Comparative figures of stocking, sales and expenses.

Stock per 100 acres.

	District A. (as butter-making before change). No.	*Change 1. (Milk-selling after change).*	*Change 2. (Milk-selling after change).*
Horses ...	5	5	5
Dairy cows ...	12	16	18
Two-year-olds ...	3	3	3
Yearlings ...	10	10	10
Calves ...	12	15	16
Breeding ewes ...	17	17	17
Other sheep ...	24	24	24
Breeding sows ...	3	3	3
Other pigs ...	53	53	53
Poultry ...	282	282	282
Stock units (cows) ...	40	44	46

It is thus indicated that the financial result of change might be that of doubling profit, and that either of such changes might bring results for District A. somewhat similar to those of the milking farms. In this connection, however, it must be remembered that a drop of 1d. a gallon in the price of milk (from 11d. to 10d.) would here reduce the profits by about £88 in the case of the first change, and about £87 in the case of the second change. At a net price of 8d. in the case of Change 1 the profit would be reduced to about £129 and in the case of Change 2 to about £99. Thus results would be very little

different from those obtained by making butter. The continuation of calf rearing which is here assumed must also be taken

Estimate of sales and expenses.

Sales.	*Change 1.*	*Change 2.*	*Expenses.*	*Change 1.*	*Change 2.*
	£	£		£	£
Horses ...	6	6	Rent and rates ...	92	92
Cattle ...	180	215	Labour (including wages of sons and daughters)	145	155
Dairy produce ...	360	405	Purchased feed ...	150	170
Sheep and wool ...	43	43	Fertilisers ...	20	25
Pigs ...	88	88	Livestock ...	94	134
Poultry and eggs ...	88	88	Others ...	70	80
Others ...	34	34			
Total ...	799	879	Total ...	571	656

Summary of approximate results District A, without change, and estimates with changes.

	Without Change.	*Estimates.* Change 1.	*Estimates.* Change 2.
	£	£	£
Sales ...	463	799	879
Expenses ...	365	571	656
Balance ...	£98	£228	£223

into account. If substitution of other feeds for some separated milk were not successfully carried out and fewer calves were

reared, or the same number of calves with smaller sales of whole milk, the results would require qualification.

The net price of milk (price less rail or other charges) and the prices or costs of feedstuffs must be two big factors in the determination in the results of any such changes. While there cannot be any dogmatic statement about the possible financial results of such changes it seemed desirable to examine the possibilities of results while farmers are considering making changes. This examination has been made with the aid of the best information which could be obtained at the present time, but every farmer who is interested must examine and qualify these figures according to his own experience and the conditions of his farm.

COSTS OF PRODUCTION AND PRICES OF MILK. A STUDY OF SOME TENDENCIES,

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AND

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On *a priori grounds* and on grounds of experience in the cases of other commodities it might be expected that the price of milk would be found to be related to—

(a) the costs of production;
or (b) the prices of milk-products;
or (c) possibly, a combination of these.

But in the wholesale price of milk for liquid consumption there may be influences of—

(d) special costs of production (other than costs necessarily incurred in producing milk for manufacturing purposes);
(e) an element of monopoly value.

Very little work has been done in the study of milk prices. During the last few years the market seems to have been dominated by ideas that the principle of charging for milk in the market for liquid consumption might be that of charging " what the traffic would bear ", at the same time of changing the scope and the nature of the " services " sold with milk; and on the manufacturing side the ostensible principle has been that of valuing milk as raw material according to the changes in

prices of imported cheese. This is ostensibly the case, but behind these appearances there may be other real influences at work.

Types of milk producers.

As regards the relation of costs of production to prices of milk, it must be said that little is known. General opinion would be that production of milk for liquid consumption, for sale at the higher prices, has been profitable: that is to say that prices have covered all the costs of the "marginal" producer, including interest on capital and remuneration of management. On the other hand, there have been opinions that production of milk for manufacturing purposes—for sale at the lower prices—has not been profitable. It is difficult to estimate the degree of truth in this opinion for milk producers may be divided more or less into three or four classes—

(a) those mainly or wholly producing for and selling to the liquid market;

(b) those selling a substantial proporiton—70 per cent. or more—for liquid consumption, and the remainder at manufacturing prices;

(c) those selling mainly to the manufacturing market.

Profitableness of dairy enterprise.

Considering the whole field of production, and taking into account the increase in number of cows and in the actual supply and sales of milk, it might be considered that milk production has been generally profitable. Nevertheless it has to be borne in mind that some other farm enterprises have been unprofitable, and there is the possibility that farmers have turned to the least unprofitable enterprise in which they could engage. The increase in milk production in this case would not be evidence of positive high profits in the dairy enterprise, but of least loss amongst the possible choices of enterprises, or of low profits in milk production as alternative to losses in other enterprises.

Cost and price of Milk.

There is at present very little evidence on the relation of costs of production to prices of milk. Most of what is known in a general may be summarised in these statements.

(1) Costs of production "per cow" or per gallon of milk show very wide variations. The costs per gallon of 52 individual farms in 1927-28 showed variations between 7d. and 16d., and similar costs for 89 farms in 1928-29 showed variations between 8d. and 17d. In each year

there were some costs higher than 17d. but these may always be regarded as special cases.

(2) Medium and higher costs are not necessarily evidence of low efficiency in production, and low costs are not necessarily evidence of high efficiency. Higher and lower costs are associated to some extent with different systems of production which again are related to different markets with varying price-levels.

(3) Medium and higher costs are not of necessity associated with low profits, and consequently low costs are not necessarily associated with high profits. But there is some evidence that the higher profits are associated with the lower costs.

The occurrence of variations in costs per gallon of milk is not at all unique in costing experience, for variations in the production costs of a commodity from firm to firm are quite well known even in industrial costings, and are common throughout agricultural costings. The reasons for such variations are many and various. Farms producing milk mainly on pasturage, with a high proportion of " summer " milk, will tend to have a low cost; and as this type will be selling largely for manufacture, they will tend to realise a low price. On the other hand, farms producing a high proportion of winter milk, or a fairly level supply throughout the year, with the necessity of housing cows for long periods and probably the necessity of buying cows to maintain supply, will tend to have high costs and need to realise fairly high prices. Indeed, the higher prices obtainable for fairly even supplies tend to stimulate this type of production; while in districts in which the demand is mainly from the manufacturing side the less intensive type of dairying is carried on. Again, there may be differences in cleanliness or other elements of quality, or of reliability of supply, between one farm and another and these are to some extent associated with costs on one side and price on the other. But the costs dealt with are usually *farm* costs only and they do not include transport charges. There are several forms of combinations of transport services with varying costs : the farmer may merely send by cart to a local depot; milk may be collected from the farm and taken to a local depot by the buyer who makes set charges for collection; milk may be collected by lorry and then railed or not (as the case may be) by the buyer but the farmer is charged with both services; or the farmer may deliver to a local station with his own vehicles and then rail, directly bearing both charges. Rail charges alone may vary between $\frac{3}{4}$d. and 2$\frac{1}{3}$d. per gallon. Charges

for collection by buyer's lorries vary between ½d. and 1d.; and farmers' own costs of delivery from farm to local station have been shown to vary between ½d. and 2d. per gallon. When these varying *transport costs* are fitted to the appropriate *farm costs*, there will be some equalising of the *total costs* of farm production and costs of delivery to buyers; but considerable variations in *total costs* will still remain. Immediate *farm costs* of production vary to some extent inversely with costs of transport, tending to be higher with nearness to market and low transport charges. But the causes of high and low *farm costs* of production are exceedingly complex. In individual cases there will be

Relation between cost per gallon and other factors.

Cost per gallon.	*No. of cases.*	*Average cost per gallon.*	*Price per gallon.*	*Cost per cow.*	*Receipts per cow.*	*Yield per cow. Gallons.*
1927-28 (63 cases).						
		d.	d.	£	£	
6—11d.	10	9.0	15.5	23.9	41.4	641
11—11.9	10	11.5	12.4	30.5	33.2	640
12—12.9	8	12.4	14.7	35.2	40.1	679
13—14.9	13	14.1	14.8	35.6	38.5	602
15—17.9	11	16.2	17.2	41.4	45.2	612
Over 18d.	11	19.9	19.2	49.8	49.0	607
1928-29 (54 cases).						
8—11d.	7	9.2	15.4	24.3	42.2	638
11—11.9	7	11.5	14.8	28.3	36.0	590
12—12.9	9	12.5	15.5	32.6	41.1	628
13—14.9	8	13.8	17.4	34.2	43.5	624
15—17.9	11	16.5	16.6	44.0	45.0	640
Over 18d.	12	22.3	22.7	52.4	54.8	564

Figures for England used in this study obtained by courtesy of Agricultural Economics Research Institute, Oxford.

high and low degrees of efficiency in the herd, and in the producer, and profits will vary with these degrees to some extent without relation to the external circumstances of the local or general

market. For short periods herds may suffer from disease losses or depreciations, and the effect of abortion, mastitis, Johnes disease, etc., on costs of production on individual farms are well-known. Bearing these conditions in mind, the following summaries of lists of individual costs may be given.

The Table on page 20 shows in simple form that it is the cases where a comparatively high price per gallon is received that relatively high costs are incurred. A good test, however, is the profit per cow; this takes the yield factor into consideration.

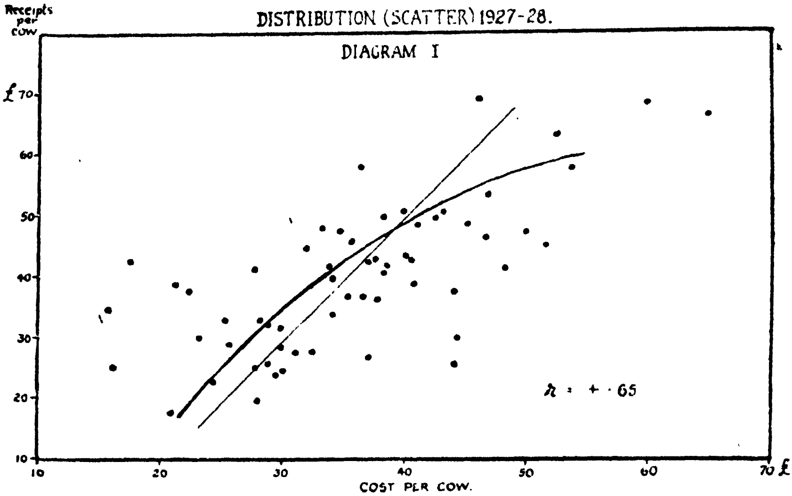
The association between costs and realised values of milk have been measured by the statistical method of correlation, and as far as these measures go they show a fairly close association between costs and prices of milk on groups of farms. The coefficients of correlation are given for different groups of farms, all England, N.E. England, and Wales.

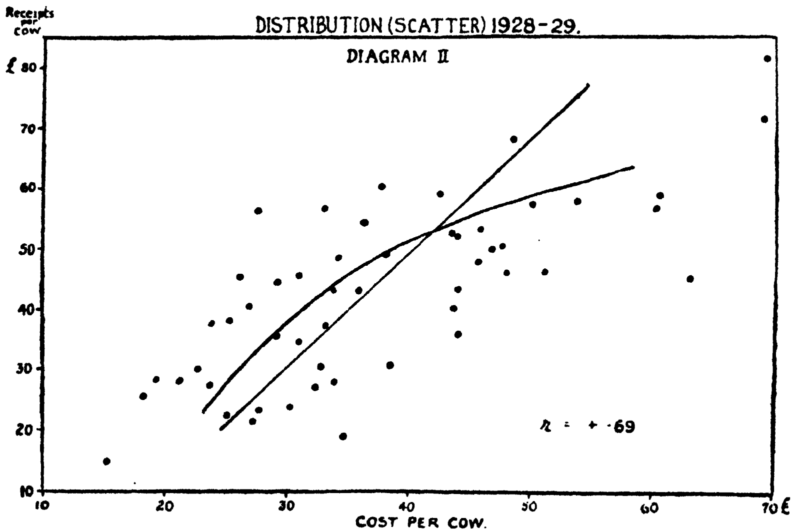
	Coefficient of correlation.
All England.	
Costs per cow and receipts per cow:	
1927-28 (63 cases)	r = + .65
1928-29 (54 cases)	r = + .69
Costs per gallon and receipts per gallon:	
1927-28 (63 cases)	r = + .45
1928-29 (54 cases)	r = + .56
North Eastern Area: England.	
Costs per cow and receipts per cow:	
1927-28 (29 cases)	r = + .73
1928-29 (29 cases)	r = + .73
Costs per gallon and receipts per gallon:	
1927-28	r = + .64
1928-29	r = + .74
Wales.	
Costs per cow and receipts per cow:	
1928-29 (26 cases)	r = + .73
Costs per gallon and receipts per gallon:	
1928-29 (26 cases)	r = + .56

There are some farms with medium and high costs suffering losses, but these figures indicate that there are necessary variations in costs in relation to conditions of sale and the prices realised.

Diagrams I. and II. indicate more clearly the relationship between the costs incurred on the cows and the total receipts per cow. It is, of course, obvious that a very large number of factors come into play in determining this relationship, and any association between the two variables depends upon the effects that such factors have upon one another. An attempt is made below to examine some of the intermediate relationships involved.

The straight lines in these diagrams indicate that it is the farmers who incur comparatively heavy expenditure per cow, that obtain the largest output per animal in the herd. As only the average relationship is shown by the straight lines, it indicates that the latter increase at a faster rate than the former. This can





be partly explained, of course, in terms of variations in the price per gallon received for the milk. But the relationship between costs per cow and receipts per cow does not appear to be a linear one, from the distribution. A curve fitted to the scatter shows that the receipts rise faster than cost for low values of the latter

and slower in the region of high costs per cow. This is, of course, to be expected as a certain amount of additional expenditure on the herd may be recouped, but eventually, a point will be reached beyond which the return will show a diminishing tendency.

The most important question which confronts every farmer engaged in the business of milk production is: At the price offered for milk, to what extent is he justified in intensifying his production? The principle of increasing and diminishing returns may operate in any phase of production operations; identical increases in the yield of milk from a cow will not be obtained for each unit increase in the amount of food she consumes. As a cow approaches her capacity to make use of the feed supplied the additional increment may be followed by a more than proportional increase in the yield of milk, as at this point, the cow will be producing at her maximum efficiency. When an attempt is made to increase the yield beyond that point, it will be generally found that a diminishing increment is obtained for equal additional quantities of food supplied. Efficiency declines, as a rule, when an attempt is made to augment output by working at a point beyond the capacity of the producing unit.

This principle does not apply in precisely the same way when it is considered in its physical and in its economic aspects. Under certain conditions a farmer may be justified in carrying production into the regions of diminishing phyical return. It does not necessary follow that the point of maximum physical output per unit of feed is also the point of maximum financial return per unit of cost. It is the relationship at the margin that is of greatest interest to the farmer; he needs to balance the additional expenses against the additional return and it will be to his financial advantage to intensify production as long as the value of the additional product exceeds the cost of producing it. From this it is apparent that even when diminishing returns prevail it is possible that production may be profitably pursued beyond the point of optimum physical returns.

As an end in itself farmers are not necessarily interested in low costs per gallon. Of course, it is desirable under any given conditions that this figure be as low as possible, but it is not always true that a farmer working at the point of lowest cost per gallon could not increase the total revenue from the herd by intensifying production and, in consequence, possibly increasing the cost per gallon. Profit is made on the margin between the price received per gallon and its cost. A small margin, however,

on a large gallonage may yield a bigger sum than a wide margin on a small amount. The financial objective is the maintenance of profit at its maximum and not cost per gallon at its minimum. In the business of milk production a few important factors have a significant influence upon this objective, and, furthermore, some of these are directly under the farmers' control. Little is known, however, of the relationships between the forces at work in the production processes; in this study, therefore, an attempt is made to apply the statistical method to the problem, in order that some of the causal factors may be examined.

Information from a good and representative sample of 26 farms is available for Wales. Data relating to 117 holdings in England have also been analysed; the latter are divided into two groups as the information was collected in different years. This inquiry, therefore, covers 143 farms. The following five factors were found to be of importance in the economy of milk production and they are used as variables in the statistical analysis.

(1) Total Costs per Cow;
(2) Total Receipts per Cow;
(3) Cost of production per Gallon;
(4) Price per Gallon;
(5) Yield per Cow.

The cost per cow can be appreciably modified by altering the amount or quality of food given and by changing the amount of labour used on the herd; and these variables are more or less adjustable. In general an increase or decrease in the amount of feed supplied and attention given to the animals will be reflected in the yield of milk. The latter is, therefore, to some extent a function of the former; the information sought, however, is the average change in yield concurrent with changes in cost per cow. The three groups will, in the following analysis be referred to by the symbols I, II and III.[1] The correlation between *yield* and *cost per cow* in the three samples is as follows :—

I, $r = +.58$; II, $r = +.36$; III, $r = +.43$.

Although the coefficients are not high they have statistical significance in view of the size of the samples. In general an increase in cost per cow is followed by higher yields. The result, of course, does not imply that in all cases the higher costs per cow are brought about by more intensive treatment of the animals. A small herd may show this result if it is badly

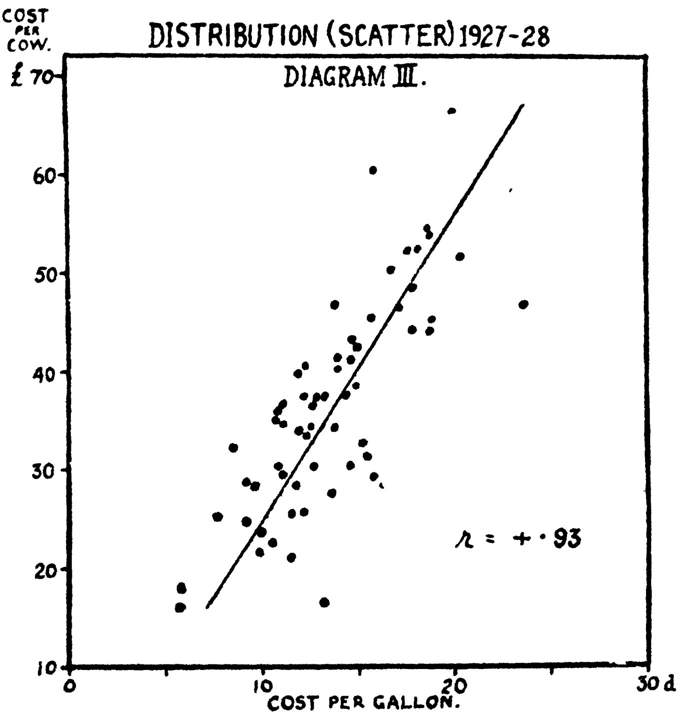
[1] I, Welsh Group; II, English first year Group; III, English second year Group.

managed, and especially so if labour is used uneconomically even though feeding is light. These would be exceptional cases, however, and in general it would be safe to infer, from the information, that the higher yields are obtained primarily as a consequence of comparatively heavy feeding and of careful treatment of the cattle.

If the rate of increase in yield were proportional to the rise in cost per cow, the cost per gallon would not change. From a practical standpoint this is of great importance; farmers wish to know if modification with regard to the intensity of working is likely to be justified. This will depend to an appreciable extent upon the relationships between these variables. The correlation between *cost per cow* and *cost per gallon* is high—

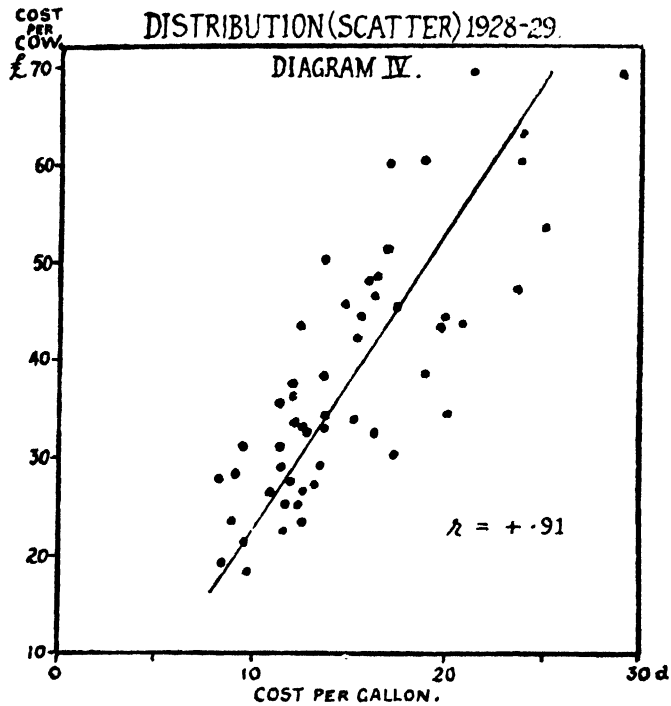
I, r = + .90; II, r = + .93; III, r = + .91.

These two variables run together very closely and the scatter diagrams below indicate this persistent tendency.



The increase in yield takes place on the average at a slower rate than the rise in cost per cow; the former fails to offset the changes in the latter. The principle of diminishing physical returns definitely comes into play in this connection as under

intensive working, milk is being produced at comparatively high cost per gallon. It should be borne in mind, however, that *high*



yields are not associated with *high costs per gallon.* The coefficients of correlation are negative for the three groups—

I, r = — .16; II, r = — .19; III, r = — .17.

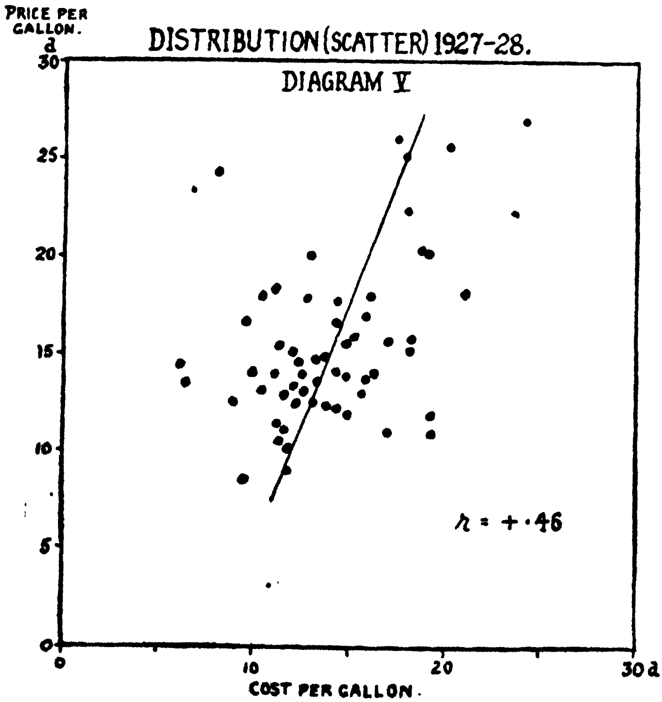
The problem, so far as the variables already considered are concerned, resolves itself into the following considerations. Increasing the outlay per cow, on the average, will result in higher yields; but as the yield rises at a slower rate than the outlay, intensifying production generally results in increasing the cost, per gallon, of producing milk. The nature of the information available enables inferences to be made to the effect that the results obtained by the study of these samples, apply with a high degree of certainty to other farms of a similar character.

A factor of supreme importance in the economy of milk production is the price received. A farmer can do little to alter this at any one time; over a period, however, he may change the average price he receives by modifying the character of his

supplies. In this investigation an attempt is made to find what influence the price factor has upon the other variables. It is the price obtainable for the milk that, to a large extent, determines the limit to which it is financially sound to intensify production. A comparatively high price per gallon may leave a bigger profit when cost of production is above the possible minimum. It is of interest, therefore, to know if a relatively high price for milk is, on the average, associated with comparatively intensive production. The correlation between *cost per cow* and *price per gallon* in the groups is as follows :

I, r = + .73; II, r = + .53; III, r = + .46.

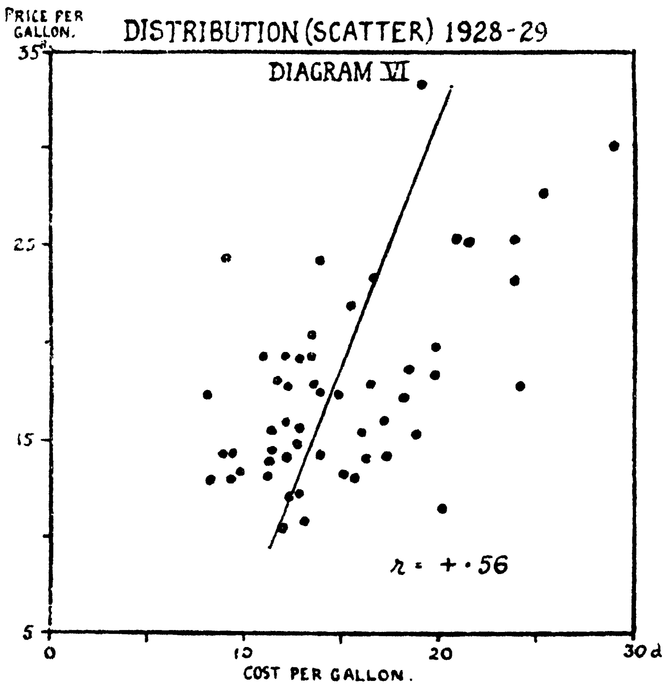
It is, in general, the farmers who receive the highest prices for their milk that incur the heaviest expenditure on the herd. This outlay, in excess of the average, is justified when the increase in yield multiplied by the price per gallon exceeds it. Again, is has been shown that with increases in the cost per cow, yields go up at a slower rate. Intensifying production in this way would be sound business if a sufficiently high price is obtainable for milk so that the value of the additional output is raised above its cost of production. The relationship between *cost per*



gallon and *price per gallon* is indicated by the following coefficients of correlation :

I, r = + .56; II, r = + .46; III, r = + .57.

It is apparent, therefore, that some farmers are working in the region of diminishing physical returns; the outlay on the herds is comparatively heavy where relatively high prices are obtainable for milk. Under some conditions this procedure is justified by the revenue obtained.



From the diagrams it is seen that the cases cluster together somewhat; but the two factors show a definite tendency to vary directly. The economy of milk production although based upon the physical relationships involved must be examined in the light of all the important factors in play. The inclusion of the price element as a variable in the study has shown that it influences the whole problem to a high degree. A farmer investigating the business aspects of this system of farming is ultimately interested in the profits from the herd, and it is apparent that this objective is attained more fully in cases where a relatively high price for milk is obtained, by comparatively heavy expenditure on the animals.

FARMERS' COST OF MILK DELIVERY IN WALES.

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A record of the time required daily for the hauling of milk, the kind of vehicle used and other data for computing the cost of the distribution of milk, was obtained for forty-six farms in the counties of Denbigh, Merioneth, Flint, Cardigan, Brecon, Pembroke, Carmarthen and Monmouth. The information was given in monthly records by the farmers concerned. The farms are situated within a range of from less than one-quarter to three miles distance from the nearest railway station, milk depot, or town to which the milk is delivered. Delivery was made by horse or by motor, and as horses and motors are generally used to some extent for other purposes, only a part of the expenses of upkeep have been allocated to the cost of delivery of milk. This proportion has been determined according to the time the horses or cars are used for delivery and the extent to which they are used for other work. Thus, if only one hour is spent in delivery, a greater proportion of the cost of upkeep must be allocated to the milk than one hour daily if the horse or car is kept mainly for that purpose. In assessing the cost of horse labour not less than one-quarter of the time of any horse engaged has been charged to the milk account. Where the milk is retailed, the question of horse labour is somewhat more simple, as the horses engaged are fairly fully employed on this work. The total cost of upkeep of horses was assessed by the farmer, and the figure given has been accepted, and similarly with motors. But only the due proportion of the total costs of keep of horses or running motors and depreciation of horses or vehicles have been charged to milk. Depreciation on horse equipment has been allowed at the rate of 10 per cent. and on motors at 20 per cent. In the case of churns, cans, measures, etc., full depreciation has been allowed. The interest on capital proportion is also included, but alternative costs not including interest are given.

Of the forty farms supplying the wholesale milk trade, eighteen of these incurred rail charges and the remainder delivered locally. Six farms only were concerned with the retailing of milk, and delivery was made by horse with one exception, where a motor was used.

The transport and delivery costs have been set out under four divisions.

(*a*) Cost of wholesale delivery, including rail charges.

(*b*) Transport costs (excluding rail charges) where all the milk is sold wholesale.

(*c*) Transport costs (excluding rail charges) for farms supplying mainly wholesale but with some retail trade.

(*d*) Transport costs of milk retailed by producers with some wholesale trade.

(*a*) Some of the farmers who rail milk send it to the industrial areas within the Principality, others send over the borders into the English counties and there are a few who supply the London market. The distance the milk is transported varies according to the town or district to which the milk is sent and the station from which it is railed. Although there are a few that rail the milk over distances of one hundred and even over the 150 miles limit, by far the greater quantity, however, is sent by rail over distances within the 20-75 miles limit. The usual charge made by the railway companies for milk sent above twenty and up to fifty miles is 1.15d. per gallon, and above fifty and up to seventy-five miles is 1.45d. per gallon, for a minimum quantity of ten gallons. This rate is for conveyance at "owner's risk." The average rail charges for the farms under consideration is 1.33d. per gallon and the costs, therefore, lie somewhere between the above mentioned railway rates. The lowest cost is for a delivery of 13,620 gallons at a rate of 0.90d. per gallon and the highest cost is for delivery of 8,725 gallons at a rate of 2.30d. per gallon. In the latter case the milk was railed a distance of about 230 miles. The total cost of distribution, including rail charges, range from 1.23d. to 3.29d. per gallon. The total costs on individual farms, together with separate costs for rail charges, are given in Table I.

A total of about 240,000 gallons or a little over 13,000 gallons per farm showed total delivery charges of nearly 2d. (1.96d.) per gallon, 1⅓d. for rail charges and about ⅔d. (0.63d.) for delivery to station.

(*b*) Information is available for twenty-one cases of wholesale delivery costs where no retailing is done. Nine of these incurred rail charges, otherwise the milk was delivered locally either to shop of retailer, creamery, milk depot, hospital or public institutions. The method of delivery was by horse and float. Without rail charges the general range of costs is between 0.27d. and 1.12d. per gallon. The lowest cost is found on a farm situated a comparatively short distance from the creamery and delivering about

36 gallons per day. The highest cost is found on a farm using two horses for deliveries of about 72 gallons per day. This farm is situated about 3½ miles from the railway station to which the milk is delivered. The average cost for all the farms is 0.60d. per gallon for an average annual delivery of 11,704 gallons per farm.

TABLE I.

Cost of wholesale delivery (including rail charges).

Total milk sent by rail.	*Total rail charges.*	*Total cost of delivery to station (including interest).*	*Total cost including rail charges.*	*Cost per gallon including rail charges.* *Including interest.*	*Cost per gallon including rail charges.* *Less interest.*	*Rail charges per gallon.*
			Horse vehicles and rail.			
Gallons.	£ s. d.	£ s. d.	£ s. d.	Pence.	Pence.	Pence.
22,203	109 9 5	27 4 6	136 13 11	1.47	1.45	1.18
11,918	59 13 9	36 16 3	96 10 0	1.94	1.89	1.20
7,245	38 9 10	24 5 10	62 15 8	2.07	2.02	1.27
7,655	38 6 1	17 18 11	56 5 0	1.76	1.75	1.20
13,620	51 6 9	18 17 1	70 3 10	1.23	1.22	0.90
13,757	68 8 11	34 4 1	102 13 0	1.78	1.77	1.19
4,689	25 4 1	31 17 7	57 1 8	1.95	1.94	1.30
24,795	113 5 9	38 3 8	151 9 5	1.45	1.44	1.09
12,450	56 1 1	10 0 6	66 1 7	1.27	1.26	1.08
7,811	35 7 6	19 3 0	54 10 6	1.67	1.66	1.09
11,995	64 19 3	20 18 2	85 17 5	1.70	1.68	1.29
19,123	180 4 1	44 18 1	225 2 2	2.82	2.81	2.26
12,671	76 8 5	20 1 2	96 9 7	1.81	1.80	1.44
26,387	133 18 1	123 14 11	257 13 0	2.33	2.31	1.21
8,725	83 12 7	21 18 11	105 11 6	2.90	2.88	2.30
			Motor vehicles and rail.			
22,253	109 9 5	39 6 8	148 16 1	1.60	1.55	1.18
3,494	25 18 3	57 4 0	83 2 3	3.29	3.13	1.80
9,134	68 2 7	40 3 7	108 6 2	2.83	2.70	1.78

The costs (excluding rail charges) for the individual farms are given in Table II. The average cost for local wholesale delivery is approximately the same as for delivery from farm to station.

TABLE II.

**Cost of delivery (all wholesale).
Horse vehicles.**

Delivered wholesale.	*Total cost.*	*Cost per gallon.*	
		Including interest.	*Less interest.*
Gallons.	£ s. d.	Pence.	Pence.
11,918	36 16 3	0.74	0.69
7,245	24 5 10	0.80	0.75
10,690	20 3 5	0.45	0.42
9,666	38 3 6	0.95	0.90
7,075	31 15 8	1.08	0.96
7,655	17 18 11	0.56	0.55
13,757	34 4 1	0.59	0.58
11,687	31 17 7	0.65	0.64
12,315	15 3 6	0.29	0.28
10,136	36 1 9	0.85	0.88
11,609	18 2 0	0.37	0.35
15,525	20 4 11	0.31	0.30
7,811	19 3 0	0.58	0.57
12,671	20 1 2	0.37	0.36
26,387	123 14 11	1.12	1.10
8,725	21 18 11	0.60	0.58
12,039	35 15 5	0.71	0.71
13,122	15 0 10	0.27	0.26
15,470	20 4 11	0.31	0.31
12,231	18 2 3	0.35	0.34
8,107	16 10 8	0.49	0.48

From the summary of the costs it will be seen that manual labour accounts for 58.4 per cent., upkeep of horses with depreciation on equipment 38.1 per cent., and interest on capital 3.5 per cent. of the total costs.

Summary of total costs.

	Horses (21 farms).	*Per cent. to total.*
	£ s. d.	Per cent.
Cost of keeping, with depreciation on equipment ...	285 1 5	38.1
Manual labour ...	360 8 3	58.4
Interest on capital ...	19 19 10	3.5
Total charges ...	615 9 6	100.0
Total gallonage ...	245,791	
Cost per gallon ...	0.60d.	

(*c*) In the nineteen cases where a small amount of retailing is carried on with the main system of supplying milk in wholesale quantities, fifteen showed delivery by horse and float and four delivered by motor. Five of them incurred rail charges, but

cost of rail transport is not included in the results given in Table III.

With regard to the retail delivery, small quantities are sold at the farm house door and in others small quantities are delivered to one or two retail customers living near the farms. In other cases the retailing of milk consists in supplying hotels or boarding houses. No attempt was made to ascertain the cost of selling milk retail at the door or even the delivery of small quantities to one or two customers. In some cases no costs in the form of

TABLE III.

Cost of wholesale delivery (with some retail).

Delivered Wholesale.	*Delivered or sold retail.*	*Per cent. of wholesale to total.*	*Total deliveries.*	*Total cost.*	*Cost per gallon.* Including interest.	*Cost per gallon.* Less interest.
Horse vehicles.						
Gallons.	Gallons.	Per cent.	Gallons.	£ s. d.	Pence.	Pence.
22,203	14	97.9	22,217	27 4 6	0.29	0.27
9,993	96	99.0	10,089	18 9 5	0.44	0.41
8,271	366	95.7	8,637	17 18 3	0.51	0.49
10,718	730	93.6	11,448	27 7 9	0.61	0.57
12,261	288	97.7	12,549	39 15 2	0.77	0.74
13,620	737	96.1	14,357	18 17 1	0.33	0.32
33,676	1,172	96.6	34,848	23 4 1	0.16	0.15
24,795	78	99.6	24,873	33 3 8	0.36	0.35
9,344	347	96.4	9,691	21 10 3	0.55	0.54
12,450	241	98.1	12,691	10 0 6	0.19	0.18
11,995	209	98.2	12,204	20 18 2	0.41	0.39
19,123	132	99.3	19,255	44 18 1	0.56	0.55
9,484	201	91.9	9,685	21 7 11	0.54	0.53
10,592	230	97.8	10,822	19 6 3	0.43	0.42
27,668	868	97.3	28,536	28 11 9	0.24	0.23
Motor vehicles.						
22,253	459	97.9	22,712	39 6 8	0.42	0.37
9,182	939	90.7	10,121	57 4 0	1.49	1.33
16,883	358	97.9	17,241	79 5 3	1.12	1.02
9,184	1,344	87.1	10,478	40 3 7	1.05	0.92

actual expenditure are incurred, although someone must take the trouble to sell at the door or to deliver. The quantities retailed and the proportion of retail sales to total deliveries are shown in Table III.

The summary which follows indicates lower costs than those

found for the farms catering entirely for the wholesale milk trade. Excluding the retail milk the cost where horses are used is 0 38d., and where motors are used 0.90d. per gallon.

Summary of total costs.

	Horses. (*15 farms*).	*Per cent. to total.*	*Motors* (*4 farms*).	*Per cent. to total.*
	£ s. d.	Per cent.	£ s. d.	Per cent.
Cost of keeping (or running), with depreciation on equipment and repairs ...	107 16 10	28.6	120 2 8	55.6
Manual labour ...	257 13 10	68.2	72 14 10	33.7
Interest on capital ...	12 2 2	3.2	23 2 0	10.7
Total charges ...	377 12 10	100.0	215 19 6	100.0
Total gallonage ...	236,193		57,452	
Cost per gallon ...	0.38d.		0.90d.	

The differences between costs here and those given in Table II arise from the heavier deliveries and the shorter distances the milk has to be hauled. In Table II the average annual *wholesale* delivery for twenty-one farms using horses is 11,704 gallons, while for the fifteen farms (Table III) the average annual *wholesale* delivery is 15,455 gallons per farm. Of the farms using motors the four cases in Table III had an average annual wholesale delivery of 14,363 gallons per farm, and the milk was delivered at an average cost of 0.90d. per gallon.

For the farms using horses, manual labour represents 68.2 per cent. of the total costs, cost of upkeep of horses with depreciation and repairs 28.6 per cent. and interest on capital 3.2 per cent. Thus, manual labour charges constitute a higher proportion of the costs than for the farms (Table II) where all the milk is destined for the wholesale milk trade. Where motors are used, the labour charges are less and represent only 33.7 per cent. of the total costs, while the cost of running the cars with depreciation and repairs is 55.6 per cent. and interest on capital 10.7 per cent.

Delivery costs will to some extent depend on the distances the milk has to be transported and on the character of the roads. It is, however, important to note that the quantity of milk carted has also a considerable influence on the cost of delivery. The figures that follow indicate the tendencies in that direction.

It will be seen from Tables II and III that for the farms using horses for the delivery of milk that the range of costs is from 0.16d. to 1.12d. per gallon. This amounts to a variation of

0.96d. per gallon. The average quantity of milk delivered per farm was 13,388 gallons and a variation in the cost of 0.96d. per gallon represents a sum of about £54 for each farm per annum. The question is, would it be possible for the farmer, by improving his method of delivery of milk, to reduce this sum. It is, however, fully recognised that the expenses incurred in the hauling of milk do not depend entirely on the organising ability of the farmer. The distance the milk has to be hauled, the steepness and the character of the roads, are factors which lie beyond the

Cost of delivery (all wholesale). Table II.

Number of farms.	*Average annual wholesale delivery.*	*Average cost per gallon.*
	Gallons.	Pence.
7	8,040	0.72
7	11,465	0.58
7	15,607	0.54

Cost of delivery (with some retail). Table III.

Number of farms.	*Average annual wholesale delivery.*	*Average cost per gallon.*
	Gallons.	Pence.
6	9,234	0.76
6	11,939	0.45
7	23,800	0.40

farmer's control. It has been shown that the quantity carried exerts a considerable influence on the costs and it is in this direction that the farmer may be able to improve his methods. Collective delivery of milk has in some parts of Wales proved practical. Producers join together and each one in his turn delivers the milk for the entire group. This works quite well where the daily production is small enough, so that one man can handle the output. To what extent this method could be developed in other areas depends on the quantity of milk to be delivered and to what extent farmers would be prepared to co-operate with one another in the delivery of milk. At any rate, it does suggest one method by which a reduction in the delivery costs would be secured.

(*d*) There are only six cases in which costs of retail delivery are available, and these are :—

(1) *Farm adjoining town.*

	Retail delivery. Cost per gallon.	*Average daily delivery. Gallons (approx.).*
	Pence.	
1st year ...	3.62	28
2nd year ...	2.50	42
3rd year ...	2.08	51

(2) *Farm $2\frac{1}{2}$ miles from seaside town.*

1st year ...	2.82	30
2nd year ...	3.00	28

(3) *Upland farm 4 miles from quarrying town.*

1st year ...	4.98	29

Farm No. (1), for which costs have been obtained for three years in succession, produces Grade A milk. It is situated on the outskirts of the town in which the milk is retailed, and for that reason very little time is spent on the road before delivery starts. Practically all the milk is sold in bottles and this reduces the labour in delivery, as no time is lost in measuring out supplies to customers. The cost of delivery from this farm has decreased from 3.62d. in the first year to 2.08d. in the third year. This reduction in the costs is due to an increase in the quantity of milk delivered and to an increase in the number of customers requiring fairly large supplies of milk. The average daily delivery has increased from twenty-eight gallons in the first year to fifty-one gallons in the third year. Over the three year period the average retail delivery cost is 2.59d. per gallon.

As compared with Farm No. (1) the costs are slightly higher on Farm No. (2), the average cost of delivery for the two years being 2.91d. per gallon. In this case the milk has to be hauled $2\frac{1}{2}$ miles and the quantity delivered is very much less than on Farm No. (1).

The highest cost (4.98d. per gallon) is on Farm No. (3), where delivery is made by motor and the milk hauled a distance of four miles.

The costs for the individual farms are given in Table IV.

The costs range from 2.08d. per gallon for a daily delivery of fifty-one gallons by horse and float to 4.98d. per gallon where an average of twenty-seven gallons is delivered daily by motor. It is thus seen that the distribution costs per gallon incurred by these producer-retailers are on the whole comparatively low. The

summary of the total costs are given below, where it is shown that manual labour constitutes the heaviest item of cost.

Summary of retail costs.

	Horses (5 farms).	*Per cent. to total.*	*Motor (1 farm).*	*Per cent. to total.*
	£ s. d.	Per cent.	£ s. d.	Per cent.
Cost of keeping (or running) with depreciation on equipment and repairs ...	162 16 9	22.3	93 14 8	43.2
Manual labour ...	398 18 3	54.5	111 12 5	51.5
Caps, bottles, cans, etc. ...	157 5 6	21.5	3 0 0	1.3
Interest on capital ...	11 16 6	1.7	8 8 0	4.0
Total charges ...	730 17 0	100.0	216 15 1	100.0
Total gallonage ...	65,177		10,437	
Cost per gallon ...	2.69d.		4.98d.	

TABLE IV.

Cost of retail delivery (with some wholesale).

Horse vehicles.

Delivered or sold retail.	*Delivered wholesale.*	*Per cent. of retail to wholesale.*	*Total deliveries.*	*Total cost, including interest.*	*Cost per gallon. Including interest.*	*Cost per gallon. Less interest.*
Gallons.	Gallons.	Per cent.	Gallons.	£ s. d.	Pence.	Pence.
10,085	2,221	82.0	12,306	152 4 0	3.62	3.59
10,778	1,120	90.6	11,898	126 16 3	2.82	2.75
15,346	744	95.2	16,090	160 5 3	2.50	2.47
10,366	1,080	90.6	11,446	129 13 6	3.00	2.93
18,602	325	98.3	18,927	161 18 0	2.08	2.06
10,437	310	97.1	10,748	216 15 1	4.98	4.79

The average daily delivery for the six cases is approximately thirty-five gallons, and the average retail cost is 3.0d. per gallon. Of this, manual labour represents 1.62d. or approximately 54 per cent. of the total costs. The average costs for the five cases delivering by horse and float is 2.69d. and for the one case delivering by motor is 4.98d. per gallon.

The average costs for the whole of the groups, together with the results obtained in a previous investigation,[1] are herewith stated.

Average cost per gallon.

	Present study.			*Previous study.*		
			Pence.			Pence.
Wholesale delivery	Horses	(36)	0.49	Horses	(18)	0.86
	Motors	(4)	0.90	Motors	(6)	1.18
	Total	(40)	0.54	Total	(24)	0.94
Retail delivery	Horses	(5)	2.69	Horses	(23)	4.70
	Motors	(1)	4.98	Motor Cycle	(1)	6.50
	Total	(6)	3.00	Trucks or Cans	(8)	4.00
				Total	(32)	4.60

The results for the two studies show a very wide range of costs and this is only in accordance to expectation, as the cost of hauling milk by individual farmers will vary according to the size of load, distance and condition of the roads. But both studies have shown that transport costs are to some extent within the control of the farmer and that journeys for the delivery of small quantities of milk entail high expenses per gallon. Where the margin of profit is small any method of reducing cost of hauling or of rail transport may make a considerable difference to the net return to the farmer.

SOME ASPECTS OF CONSUMPTION, SUPPLIES, AND PRICES OF TOMATOES AND CUCUMBERS.

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There is scarcely anything more remarkable in the recent history of the dietary of the British people than the rise in importance of salad fruits and vegetables. The cucumber has

[1] Pryse Howell and Meredith. Farmers' Costs of Milk Delivery in Wales. *Welsh Journ. Agr.*, Vol. III, 1927.

long been known and commonly used for food in Europe and the East: its cultivation is both ancient and widespread. It was supposed to have been introduced, or possibly re-introduced, into England in 1578; but as the "cowcumber"—a name even recently used in rural districts and commonly regarded as a solecism—it is described in literature of that century. Besides being eaten it was also used for decorative purposes, probably in its ripe form. By the 18th century it was commonly grown for sale in market gardens near London. At this time the plant was grown both under protection by mild forcing and in the open air; and both these systems of production continued until towards the end of the 19th century. Between 1860 and 1880 there was very considerable commercial production, near London, and near Sandy in Bedfordshire, and St. Neots, Huntingdon. Open-air production near London was declining in the early 'seventies, and the main part of the crop was grown in frames on hot-beds and in houses. Some of the houses were of the span-roofed type now common, but others were "long, narrow, lean-to hot-houses against low-brick walls, 60 to 70 feet long and 8 to 10 feet wide. Through the roof being so very low headroom was gained by a sunken pathway along the middle, several feet deeper than the floor level. On each side of the pathways, and extending the whole length of the houses, are wooden troughs 3 feet wide and 9 or 10 inches deep, with perforated bottoms." The heating apparatus was primitive "consisting of a row of earthenware pipes running all round the house, forming a flue which supplies both top and bottom heat to the plants. This flue is placed close under the troughs that contain the roots." Considerable success was attained with even more primitive structures, but towards 1880 the men with the span-roofed houses "were enabled to send a supply to market at every season of the year." Yet outdoor production still continued and it was said that the Bedford and Huntingdon growers sent 500 to 600 tons per week to London during the season, but the outdoor must have been a comparatively short season.

Production has since increased, but the outdoor growing of the salad cucumber has now nearly disappeared. The characteristic salad fruit has long been a glasshouse product.

The estimated production of cucumbers, according to the Report on Agricultural Output, was 377,000 cwts. in 1925 and there is evidence that home production is increasing. Unfortunately accurate statistics of imports of cucumbers into this country are not available, because they are not separately enumerated in the Trade Returns. The principal source of

imports, however, are the Netherlands, and the following total figures give the Netherlands' exports of fresh cucumbers into this country in recent years.

	Quantity.	*Value.*
	Tons.	£000
1929	2,214	33
1930	2,608	40
1931	2,749	46
1932	1,143	26

These imports, however, only form a comparatively small proportion of the total consumed, and the great part of the total supplies are home produced. An estimate of the consumption of cucumbers would only be slightly over a pound per head.

The rise of the tomato is far more striking than that of the cucumber. It was introduced early from South America but did not rise to importance until after 1850. It is recorded that the tomato has gone through three stages of development and use during its production in Europe. At first the fruit was very small and the fruited plant was used for decorative purposes, and even until recently it was known as the Love Apple. The small fruits were also used for making sauces, mainly for flavouring, then as selection improved, varieties and strains and size increased, it became an article of food in both cooked and raw forms but its common use as a salad fruit is comparatively recent. Soon after the middle of the last century it was commercially grown, and more particularly after 1870 in connection with cucumbers in the neighbourhood of London. The tomato was grown as an out-door crop, first in the market gardens near London but also in other parts of the country and it is still so grown to some extent in the Vale of Evesham. Up to 1875 the main part of the crop seems to have been grown out of doors after the plants had been raised under protection, but about this time some specialisation of forcing was occurring. Since about 1890, however, the main part of the commercial crop of this country has been grown under glass. The invention and improvement of systems of heating by the circulation of hot water, giving economical and effective heating under control and without fumes, made possible the modern system of glasshouse production.

In 1877 it was said that " it was not until recently that the merits and usefulness of the Tomato or Love Apple have been known," but " within the last ten years " it has " obtained a larger share of public favour than perhaps any vegetable has been known to do in the same short space of time." And this

was at a time in which the main part of the crop seems to have been grown out of doors, and some of the fruit had to be picked green and ripened under glass. At this time imports came mainly from Italy, during the early part of the summer. This fruit also was said to be picked green, packed in sawdust, and left to ripen in transit and store; but some imports were obtained from other countries. Even the "canned" tomato assisted the general development of public taste for the fruit. By 1875 there was an important canning industry in U.S.A. and considerable areas were grown in the states of New York and New Jersey for canning purposes. Of this product it was said: "Of all the tomatoes imported into this country none are comparable with the canned fruit of American growth." From about 1890, but more particularly from the beginning of this century, there was enormous increase in the trade and in the consumption of tomatoes in this country. Total imports in the years 1900-04 were about 928,000 cwts., while in 1931 the total was nearly 3 million cwts.

Analysis of recent supplies of Tomatoes.

Home production has been slow to develop and supplies for consumption in this country have come mainly from the Canary and Channel Islands and from Holland. The home supply, however, has been increasing steadily and the value of the output has been estimated in recent years at about £2½ million, only slightly less than the output of cheese or wool. In 1931 the home supply was estimated at 1,050,000 cwts. or about 27 per cent. of the total consumed in this country. The analysis of the main commercial supply in this country in recent years is as follows:

	1929.		*1930.*		*1931.*	
	Total 000 cwts.	*Per cent. of total.*	*Total 000 cwts.*	*Per cent. of total.*	*Total 000 cwts.*	*Per cent. of total.*
English ...	1,050	30	1,050	27	1,050	27
Channel Islands	715	21	822	21	745	20
Dutch ...	585	15	678	17	731	19
Canary Islands	1,171	34	1.859	35	1,296	34
Total ...	3,471	100	3,909	100	3,822	100

The home crop begins to move to market in April or slightly earlier according to season, and the bulk of supplies are marketed in June and July. Production declines gradually and falls very low in October and November. Supplies of tomatoes coming into this country from the Channel Islands and the Canaries are grown mainly in the open and costs of production are naturally much lower than in this country. Supplies are not always directly competitive with those from home sources. Canary supplies begin to arrive in October and November and continue to increase, rising to a maximum in April or May. Tomatoes from the Channel Islands reach this country only in small quantities until July and peak supplies arrive normally in September. Supplies from the Netherlands follow practically the same seasonal trend as home grown tomatoes. Shipments are heaviest from June to September and then cease altogether early in November. Tomatoes from the Netherlands are mainly glasshouse grown although small quantites may be grown outdoors. The Dutch supplies and to some extent those from the Channel Islands enter directly into competition with home supplies in so far as they are marketed during the same period, and heaviest home supplies and heaviest arrivals from Holland frequently coincide.

The increase in consumption of tomatoes in this country is illustrated in the Table below showing the trend of imports. Unfortunately no reliable statistics are available to show the increase in home supplies over the same period. But the great increase in the area under glass in the principal tomato districts like the Lea Valley and Worthing districts since 1900 indicates that the great increase in home supplies has coincided with the growth of imported supplies.

Imports of tomatoes into United Kingdom.

	Quantity.	*Total value.*	*Value per lb.*	*Imports per capita.*
	Cwts.	000 £s.	d.	lbs.
1911-13	1,457	1,207	1.8	3.6
1922	2,320	4,148	3.8	5.5
1924	2,438	3,772	3.3	6.1
1926	2,302	4,066	3.8	5.7
1928	2,805	4,417	3.4	6.9
1930	3,052	4,545	3.2	7.5
1931	2,937	4,566	3.3	7.3
1932	2,442	4,356	3.8	5.8

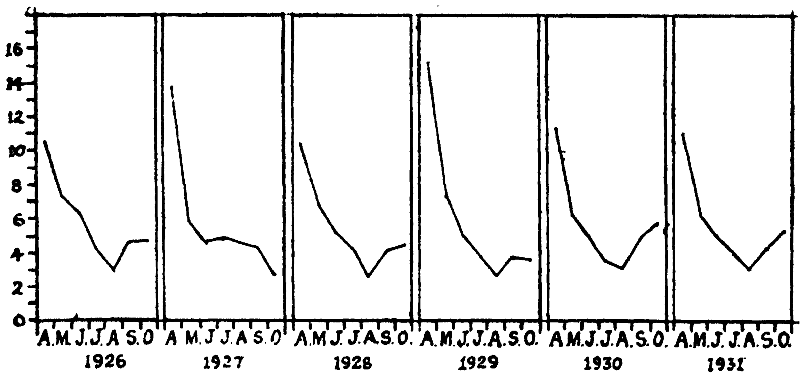
The total consumption per head of tomatoes is estimated at present at slightly over 10 lbs. and about a third of this

total is home grown. The expansion of the industry in this country since 1918 has been largely induced by the increase of demand for tomatoes and the consequent profitable level of prices. Up to quite recently there were no official quotations of prices available and those quoted in the Diagram are Covent Garden prices published weekly in the "Fruit Grower."

DIAGRAM 1.

Market Prices of English tomatoes, 1926-31.

(Shillings per 12 lbs.).



The weighted average yearly prices were approximately as follows :—

	Per doz. lbs.		*Per doz. lbs.*
	s. d.		s. d.
1924	6 0	1928	5 6
1926	6 0	1929	5 8
1927	5 7	1930	5 4
		1931	5 5

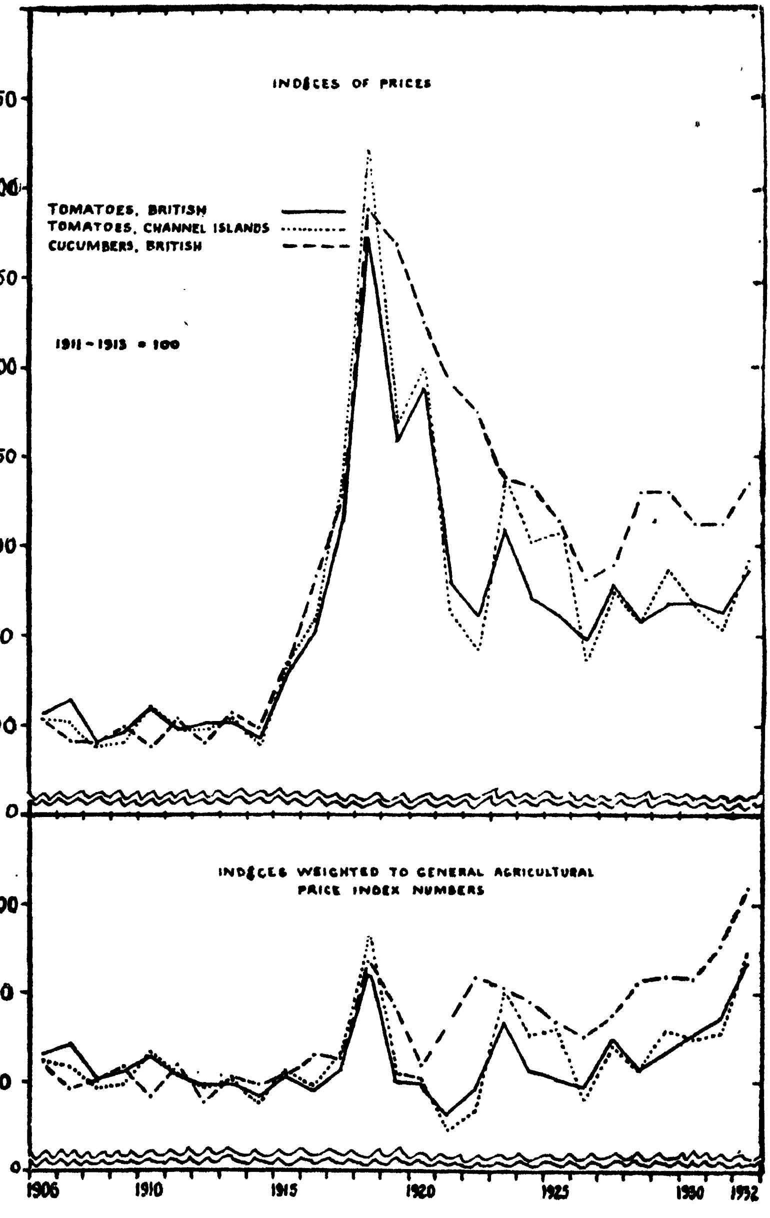
Price quotations for 1925 omitted because they are not comparable.

Throughout the period, prices realised by growers in most districts were satisfactory and although profits had fallen with the decline in prices from 1926, confidence was maintained and the industry was still expanding especially in small units on the outskirts of the large provincial consuming centres.

The general course of wholesale prices is well illustrated in the Diagram below, which shows the Ministry of Agriculture Index Numbers for Tomatoes and Cucumbers and for all agricultural produce.

DIAGRAM 2.

Indices of Prices of Tomatoes and Cucumbers, 1906-1932, and the same figures weighted to the Index of General Agricultural Prices for the same period.



Prices of tomatoes on the whole were well maintained even in recent years compared with those of general agricultural prices,

and it is easy to understand that glasshouse production increased over the period to meet the rising demand.

Seasonal variations in supplies and prices of Tomatoes.

The cultivation of tomatoes under glass is an enterprise requiring intensive application of capital in the form of houses and equipment, and one that needs accurate technical knowledge and a carefully trained staff of workers. Details of knowledge of soil, cultivation and manuring, suitable varieties for the market, adequate heating of the houses, steaming and sterilisation of the soil, and propagation of plants have partly to be acquired by experience of the actual conditions at the nursery. While a great deal of general knowledge or information is available, practices in each individual nursery differ according to special technical circumstances and the special requirements of the market and the policy followed by different managers.

One of the principal features of the home grown crop is the seasonality of production. In most areas supplies begin to move to market in April and increase to a maximum in June or July, to fall off gradually and cease in October or November. But seasonality varies in different nurseries. Some growers make an effort to obtain a high proportion of early supplies at relatively high prices while perhaps reducing the total yield of crop. Others aim at a high total yield although the bulk of supplies may be marketed in mid- and late summer when prices have reached a low level. The distribution of total supplies in the principal tomato areas in England for 1929 and 1930 is set out in the Table below along with the distribution shown by a prominent nursery in the Lea Valley for the same years and for the period 1926-30.

Monthly distribution of home-grown tomatoes.

	Estimated total English tomatoes, 1929–30.	*Lea Valley Nursery, 1929–30.*	*Lea Valley Nursery, 1926–30.*
	Per cent.	Per cent.	Per cent.
May ...	6.6	7.0	7.4
June ...	25.8	40.0	35.2
July ...	29.0	23.2	28.8
August ...	17.0	14.2	15.4
September ...	11.6	11.8	12.0
October ...	6.7	3.8	5.0
November ...	3.3	—	1.2

The peak of total English supplies occurred in July in both years whereas the highest supplies from the Lea Valley nursery

were marketed in June. The distribution of the crop, however, varies slightly from year to year although the trend in general is fairly constant. In this particular nursery the June output for 1929 and 1930 amounted to about two-fifths of the crop. The actual proportions of the crop marketed in May, June and July in each year of the period 1926-30 were as follows :

Per cent. of total quantities sold.

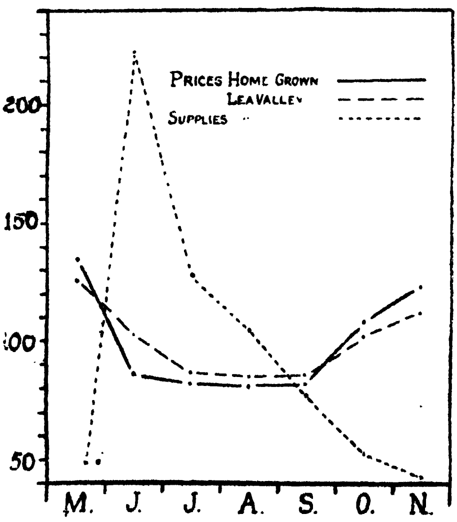
	May.	*June.*	*July.*	*Total, three months.*
1926	7.6	28.6	28.3	64.5
1927	10.9	38.5	20.1	69.5
1928	4.2	29.7	24.8	58.7
1929	6.3	38.0	24.3	68.6
1930	8.0	42.4	21.7	72.1

Small quantities of tomatoes were marketed in two years in the last week of April, but the amounts were too small to be included in the statement of monthly distribution. Other English supplies normally enter the market about the second week in April, but quantities remain small until the beginning of May.

Prices of English tomatoes rule high in the opening months of the season and as supplies increase, prices decline, at first

DIAGRAM 3.

Seasonal variations in supplies and prices of home-grown tomatoes, 1926-31.



gradually and then rapidly to a low level towards the end of July and during August. Prices realised in the month of April and early May are luxury prices and they vary considerably from centre to centre. As the season progresses and supplies increase, prices decline and normal home grown supplies enter into competition with supplies from overseas. The seasonal variation in wholesale prices of home grown tomatoes is illustrated in the Diagram using Covent Garden weekly quotations of prices and actual prices received weekly by a Lea Valley grower.

The Diagram illustrates the familiar phenomena of heavy supplies and low prices and lighter supplies and higher prices. The information examined here relating to the Lea Valley nursery shows that this grower has been able to market the crop reasonably early and to obtain better average returns than are indicated for the home grown crop as a whole. But the problem set to any grower by this extreme variation of supplies and prices is a difficult one and it can only be solved by growers individually by close study of their own circumstances at the nursery in relation to conditions in the market which they supply.

The actual variations in cash received for tomatoes at this nursery for the period 1926-30 are shown by the following figures of total monthly receipts.

	Quantity strikes (12 lbs.).	*Total cash.*	*Average price per strike.*
		£ s. d.	s. d.
April ...	11	6 12 0	12 0
May ...	2,374	1,142 9 3	9 7
June ...	12,395	4,377 12 0	7 1
July ...	8,359	2,173 8 9	5 2
August ...	5,382	934 15 11	3 6
September ...	4,158	507 2 7	2 4
October ...	1,785	221 9 4	2 6
November ...	433	51 10 0	2 4½
		£9,414 19 10	

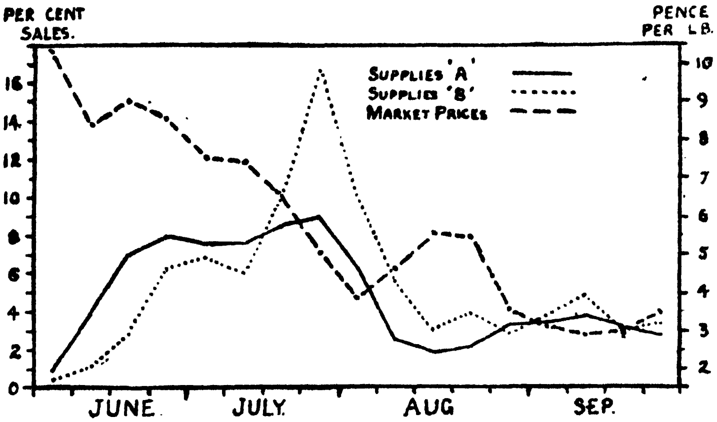
Operations were fairly profitable in 1926, 1927, 1928 and 1929, but receipts declined somewhat in 1930 and declined still further in 1931. Costs, however, have been adjusted to some extent and although profits have been made they have been barely sufficient to pay a reasonable salary for management after allowing interest on capital. The nursery is managed efficiently and the soil is quite new and all the equipment is in good condition and suitable for the purposes. Yields have been heavy and fairly consistent, making an average of over forty tons of produce to the acre over the period. But experience at the

nursery and the examination of the main economic features of its operation over this period indicates clearly the difficulties that have to be solved by the management if profits are to be earned, even though a high normal yield of produce is fairly easily obtainable.

The effect of the distribution of the marketable produce over the season on the actual receipts of the nursery is well illustrated in Diagram 4, where the weekly marketings of two adjacent nurseries are compared. The curve of average price has been included weekly so that the opposite movements of supplies and prices may be compared. The two nurseries are operated in the same district and served the same market and the cash receipts over the season in " A " was £582 and in " B " £589 for almost equal quantities of produce.

DIAGRAM 4.

Trend of supplies in two nurseries.



The diagram shows clearly the high concentration of supplies from " B " during July, when the price had dropped to a fairly low level as compared with the earlier disposal and more even distribution of produce over June and July in " A." This is, of course, not entirely a question of management; soil and situation are important factors, and the particular variety grown also influences the distribution of crop. Again, some nurseries grow a combination of crops, which makes it more difficult if not impossible to take advantage of the early market for tomatoes.

Quality of Produce.

As with all farm and garden crops the quality of tomatoes supplied to the market is one of the principal factors determining

the price received by the grower. Quality is decided partly by the variety grown, the general cultivation, heating of houses, manuring of the plants and the grading and packing of the produce for the market. Quality in tomatoes covers size, flavour and condition, and the grower has to pay as much attention to these features after the crop is ripe as to the general technique of production. On the central markets, special grades of tomatoes are recognised and most growers pack to these designations. But grading varies in each individual nursery and the variation in quality within grades is reflected in the prices paid to growers. The quality of the produce in every nursery varies from month to month as the season proceeds and average prices received are influenced partly by this common feature.

The analysis of the grade returns for the Lea Valley nursery selling all the produce in Covent Garden for the period 1926-30 provides interesting information.

Analysis of yields and values of tomatoes by grades. (Covent Garden grades).

Grades in order of quality.	*Per cent. of total quantity.*	*Per cent. of total cash receipts.*	*Average price per strike.*
			s. d.
Pink and White ...	35.7	41.9	6 4
Pink and White X	25.7	27.5	5 9
Blue ...	7.5	7.4	5 4
White ...	18.2	15.9	4 9
Blue and White ...	5.1	2.0	2 1½
Miscellaneous ...	7.8	5.3	3 9
Total ...	100.0	100.0	5 5

Strict grading and standardisation of grades by each packer facilitates handling at the market and results in higher prices for produce. The quality of tomatoes grown at this nursery is of a high order and the management pay particular attention to the display of the produce to the best advantage by good packing and careful grading. The variations in prices received for the different grades over this period as shown in the above Table indicate clearly the effect of high quality produce and strict grading on the total cash receipts from the crop.

" Quality," however, has no absolute meaning. It is definitely related to consumers' preferences. The demand for tomatoes has varied considerably from district to district. But the definition of quality at present varies only in regard to size of fruit, and there is some evidence that demand is gradually becoming more uniform throughout the country.

In this nursery 61.4 per cent. of the total produce over the period was placed in the two best grades and these accounted for nearly 70 per cent. of the gross receipts.

The quality distribution of the tomato crop varies slightly as the season advances. The best quality produce is picked in the peak months of the season and the bigger size fruit and the cruder sorts towards the close. The Table below shows the monthly distribution of supplies into grades for the period 1926-30 for the Lea Valley nursery.

Percentage monthly distribution of grades, 1926-30.

Month.	*P.W.*	*P.W.X.*	*Blue.*	*White.*	*B.W.*	*Miscellaneous.*	*Total.*
April ...	27.3	27.3	—	27.3	9.1	—	100
May ...	35.4	27.1	16.0	13.6	2.8	5.1	100
June ...	40.4	28.0	8.4	13.6	3.3	6.3	100
July ...	35.7	23.0	6.3	20.5	5.3	9.2	100
August ...	31.5	22.7	6.7	20.8	5.4	9.9	100
September	30.5	28.7	4.1	23.2	6.8	6.7	100
October ...	24.9	24.2	7.3	24.3	11.1	8.2	100
November	15.0	19.9	4.2	26.5	15.2	19.2	100

Comparatively heavy supplies of the lower grades of produce appear in the months of October and November when total quantities are relatively light and the general clearing up for the season occurs. The general standards of grading and packing of tomatoes in this country are by no means all that could be desired. Fruit is packed frequently in an over ripe condition and on many nurseries there is little success in standardisation of grade designations from week to week and from season to season. There are organisations in the industry which are helping to fix and describe standards and to interest growers in the importance of good grading and packing. Lately the National Mark Scheme for tomatoes has defined grades and standards which are acceptable to the trade and it is to be hoped that this will lead to greater attention being given to this end of the producers' tasks.[1]

Cucumbers: Supplies and Prices.

In a large number of nurseries, notably in the Lea Valley, cucumbers are grown along with tomatoes. In some nurseries they are the principal crop while in others both tomatoes and

[1] For a description of qualities, packs, etc., see *Report on Preparation of Fruit for Market*, Ministry of Agriculture Economic Series, No. 24, pp. 67-74; and Ministry of Agriculture Marketing Leaflet, No. 10.

cucumbers are of equal importance, being frequently grown in the same houses in alternate seasons. The tendency in the Lea Valley area in quite recent years has been to grow more cucumbers and less tomatoes, on account of very severe competition in the market for tomatoes and consequent low prices for bulk supplies. During the last ten years production of cucumbers has increased considerably in this country, but there is no actual record of the increase in home supplies. Imports of cucumbers come mainly from the Netherlands, but as was shown above, these only form a comparatively small proportion of total supplies.

The Table showing seasonal distribution of these imported supplies, however, is interesting for comparison with similar data of home production.

Exports of cucumbers from Netherlands to Great Britain.

	1929.		*1930.*		*1931.*	
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
	Tons.	£000	Tons.	£000	Tons.	£000
March ...	79	1	240	12	203	9
April ...	112	5	165	6	362	14
May ...	25	1	120	3	120	3
June ...	557	10	723	10	694	10
July ...	791	8	835	6	850	7
August ...	522	4	371	2	380	2
September	102	1	137	1	137	1
October ...	26	—	17	—	3	—
Total ...	2,214	33	2,608	40	2,749	46

Imports commence early in March and cease almost entirely towards the end of October, and the import season coincides with that for the home grown crop. The peak of home grown supplies, however, occurrs in May and precedes by a month or more the peak for imported supplies.

The course of prices for home grown cucumbers have followed fairly closely the trend outlined above for tomatoes, but published market prices are not available for any continuous period to enable a close study to be made of the trend of price movements. Information from the Lea Valley nursery throws light on some features of the home crop in recent years.

Monthly supplies and prices.

The cucumber season begins about one month earlier than that for tomatoes. Small quantities are marketed in March and the peak supplies appear in May. The season usually terminates in October or early November. The monthly variations of supplies and prices for three recent seasons are shown in the following Table.

Monthly variation of supplies and prices. Lea Valley Nursery.

	1928.		*1929.*		*1930.*		*Average three years.*	
	Per cent. of quantity	*Average price.**	*Per cent. of quantity*	*Average price.**	*Per cent. of quantity*	*Average price.**	*Per cent. of quantity*	*Average price.**
		s. d.		s. d.		s. d.		s. d.
March ...	0.2	15 5	1.0	18 7	0.2	18 10	0.4	17 7
April ...	15.7	12 8	21.5	14 11	12.9	15 9	16.7	14 4
May ...	21.8	13 1	26.2	10 7	19.4	12 4	22.5	12 0
June ...	16.8	12 2	15.7	10 11	16.1	12 5	16.2	11 10
July ...	17.2	10 10	15.5	7 6	11.6	9 9	14.8	9 4
August ...	11.9	11 9	13.9	7 8	16.8	9 11	14.2	9 9
September	12.0	6 6	6.0	7 5	14.3	8 11	10.8	7 11½
October ...	4.4	7 1	0.2	7 3	8.7	8 2	4.4	7 6

* Average price per flat.

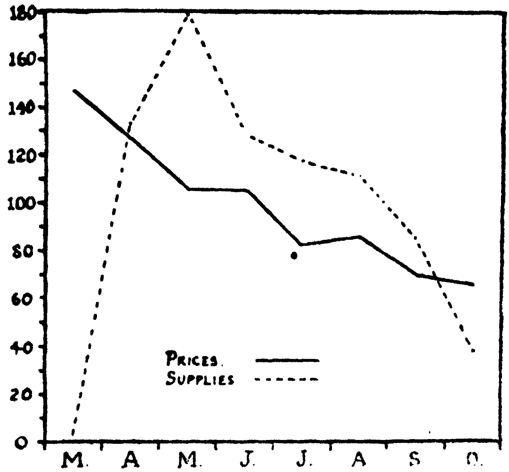
The prices of cucumbers show an almost steady downward trend during the season, but the fall tends to be more rapid in the early than in the late months of the season. Supplies rise sharply after the first weeks of cutting to a peak in May, and then decline. The seasonal weighted averages of prices received for produce at this nursery may be compared with the mean of monthly prices.

	Seasonal weighted average price per flat.	*Mean of monthly prices per flat.*
	s. d.	s. d.
Season 1928 ...	11 1	11 1½
Season 1929 ...	10 7	10 7¼
Season 1930 ...	11 2	12 0

Taking the average " flat " over the season as containing about 40 cucumbers, the average price received by the producer over the three seasons was about 8¼d. each.

DIAGRAM 5.

Seasonal variation in supplies and prices of cucumbers. Lea Valley Nursery.



The actual monthly variation in cash receipts from cucumbers again illustrates the seasonality of production.

Monthly cash receipts, total three years, 1928-30.

	Total cash.	*Per cent. of total.*
	£ s. d.	
March ...	35 5 10	0.9
April ...	875 0 2	21.7
May ...	940 14 6	23.2
June ...	824 2 0	20.2
July ...	465 11 0	11.5
August ...	470 1 6	11.6
September ...	335 9 0	8.3
October ...	106 8 6	2.6
Total ...	£4,052 12 6	100.0

Changes in the market position.

The foregoing study has illustrated the general position in the markets and variations in supplies and prices during recent years, but a considerable change in the general conditions occurred in the autumn of 1931. Great Britain then went off the gold standard of foreign exchange and in so far as exchange rates became uncertain or the value of the £ in terms of the currencies of the countries from which these goods are imported was subject to depreciation, purchase was made more difficult and more expensive in terms of sterling. Then import duties

were imposed and have subsequently been both retained and increased. It is expected that on a future occasion it may be possible to indicate the changes in the seasonal variations in supplies and prices, and in the level of prices, that have resulted from these changes in the conditions of the import trade. But at present it may be said that the duty on tomatoes does not appear greatly to have affected general production in 1932, but in the autumn it was reported that " considerable efforts are being made all over the country to increase the glass acreage of this crop, although the duty seems definitely less than the case requires." Similarly, in the case of cucumbers the present information is that general production was not much affected in 1932, but as regards 1933 it was said that " the duty will no doubt help on home production, particularly on the land of small growers with glass."

The changes in the import duties are outlined below :

Customs duties and imported supplies.

An import duty on fresh cucumbers was among the first to be imposed under the tariff policy of the present Government in this country. This order, dated the 24th of December, 1931, was made under the Horticultural Products (Emergency Customs Duties) Act, and provided for duty on imported cucumbers at the following rates :—

March 1—June 30 (inclusive) 12/- per cwt.
July 1—November 30 (inclusive) 8/- per cwt.

No. 2 Order of the same Act, dated the 21st of January, 1932, imposed a customs duty on tomatoes imported from foreign countries as follows :—

June 1—July 31 (inclusive) 2d. per lb.
August 1—October 31 (inclusive) 1d. per lb.

Under the Imports Duties Act, 1932, a general 10 per cent. ad valorem duty was imposed on all foreign imports not subject to exemption, with provision for " additional " duties by Treasury Order in accordance with the provisions of the Act. The position for 1933 is therefore, " Such a rate of duty as will, with the general ad valorem duty chargeable under Section I. of the Import Duties Act, 1932 amount to "

Cucumbers : from 1st March to 30th November, 8/- per cwt.
Tomatoes : from 1st June to 31st July (inclusive) 2d., per lb.
from 1st August to 31st October (inclusive), 1d. per lb.

The period of duty coincides fairly well with the marketing season of home grown produce and in the case of tomatoes it

is reduced to a half after the 31st July, when the peak of home supplies is over, and prices have reached a low seasonal point. These duties will affect imports of cucumbers, as supplies come mainly from the Netherlands, but imports of tomatoes from the Channel Islands are exempt so that the duties mainly affect Canary and Dutch supplies. The Channel Islands supplies in 1931 were more than a quarter of the total imports and they arrive mainly during the season of home production.

The effect of the duties in the first year has been to reduce the total imports of both these products. The total tonnage of cucumbers from the Netherlands in 1932 was only 1,143 as compared with 2,749 in 1931. Supplies in the early months from March to June, when prices were relatively high, were not seriously reduced, compared with previous years, but the figures for July and August, usually the peak months of supply, were less than a third of the usual quantity in recent years. The actual distribution of exports from the Netherlands in 1932 was :—

	Tons.		*Tons.*
March ...	201	July ...	232
April ...	210	August ...	133
May ...	53	September	40
June ...	266	October ...	8

The quantity of tomatoes imported from the Channel Islands (no Customs Duties) was 822,000 cwts., an increase of 77,000 cwts. on 1931. The Dutch supplies of tomatoes were considerably reduced in 1932, to 468,000 cwts., a contraction of 268,000 cwts. compared with 1931. Total Dutch supplies in 1932 were only 64 per cent. of the 1931 total. It is easy to understand that the Duties have effected a reduction in Dutch supplies, because they enter directly into competition with home produced tomatoes and the seasons coincide. In addition to the duty, the sterling exchange has depreciated by not less than 25 per cent. in relation to the Dutch Gulden, thus making purchase more difficult.

The normal season of imports of tomatoes from the Canary Islands is from October to June, and peak supplies arrive throughout the winter and spring months. Shipments of these tomatoes are therefore only affected by the duty at the beginning and the end of the season. Total imports from this source

amounted to 974,000 cwts., compared with 1,296,000, a reduction of about 25 per cent.

The final position in 1932 is set out in the Table on a monthly basis.

Imports of tomatoes, 1932.*
000 cwts.

	Channel Islands.	*Dutch.*	*Canary Islands.*	*Other countries.*	*Total.*
January ...	14	—	111,923	893	112,830
February ...	—	—	110,408	61	110,469
March ...	—	100	87,000	1,089	88,189
April ...	2,982	566	108,661	94	112,303
May ...	52,870	12,918	116,144	4,617	186,549
June ...	127,895	46,721	113,061	1,367	289,044
July ...	151,738	92,521	57,515	556	302,330
August ...	94,427	139,802	595	938	235,762
September	178,371	112,805	763	1,611	293,550
October ...	196,834	55,884	4,443	1,201	258,362
November	16,344	6,642	65,923	786	89,695
December	633	598	198,370	4	199,605
Totals ...	822,108	468,557	974,806	13,217	2,278,688

* From the "Fruit Intelligence Notes" published weekly by the Empire Marketing Board. The grand total figure differs slightly from that given in the official Board of Trade returns, but the classification above sets out position approximately.

MANUAL LABOUR REQUIREMENTS OF LIVESTOCK ON WELSH FARMS.

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In the discussion of agricultural topics there is frequent mention of the efficiency of labour in the cultivation and harvesting of farm crops. New machinery and labour-saving devices are continually being introduced to save labour or raise its productivity. The trend at the moment, especially in some countries overseas, is towards a completely mechanised crop husbandry. Elaborate machines like the combine harvester are utilised to increase output per hour and to carry out in one process what formerly consisted of a series of separate processes entailing considerable hard labour. The march of mechanisation has not affected the management of livestock to nearly the

same extent. But the milking machine; cream separator; barn machinery, and various devices for conveying feed and manure have certainly effected a considerable saving of manual labour time in livestock attendance, and eliminated a great deal of heavy, uninteresting, or unpleasant work. Livestock farming on most farms in this country, however, still demands the intimate contact and personal attention of the workers to a high degree. This is especially true of small stock-raising farms, where there is scope for but a few of the simpler mechanical devices. On Welsh livestock farms, members of the family provide the greater proportion of labour and also the intimate care and interest necessary with young stock. The actual labour time allowed is hardly considered to enter into the cost of production of the animals in quite the same way as rent of tenant farms or cost of feedstuffs, and the financial results of the farms are only judged by the family income available from the combination of enterprises.

On smaller farms, say with less than £1,000 capital in live and dead stock, run mainly or wholly by family labour, the bulk of the income from the farm will consist of earnings of labour. Under nearly all circumstances a number of individual farms would show financial " loss " if labour-time were valued at the cost of wage-paid farm labour, or at the estimated value of the labour-time if engaged in another industry; and in periods of economic depression many farms would show such " loss ". Where, as in some cases, manual labour is the largest *single* factor in production (the highest individual item of cost) the value of the labour may be said to be that of the residuum of the value of the product after all actual expenses and depreciations have been met. Although there is danger in this method of computation of the value of labour, and although there should be comparison of such value with the value in an alternative occupation, or a comparison of such value with the cost of wage-paid labour, there cannot be any doubt that some family labour is given to livestock without immediate counting of cost or value. Sometimes there is no immediate alternative use for such labour and consequently no immediate alternative value. Failure to use labour may reduce the total income of the farm, although it may raise the rate of earnings per hour of labour used.

Thus it may be that more labour is used on a given number of stock than would otherwise be the case if the farm were larger or carried more stock. This use of additional labour may take the form of more extensive application of labour—

that is, use of more labour in good forms and by good methods; or it may take the form of some waste of labour—that is use of labour in poor forms or by poor methods. Very intimate or detailed care and attention to young stock may not be waste of labour, although after a certain point is reached it yields only a low return, unless there is a possible alternative use which would be more profitable. But continued use of daily labour in cleaning sheds, &c., with poor floors may be a waste if a relatively small initial expenditure of labour on improvement of floors would make a substantial reduction in daily requirement. Failure to lay or clear drains, to make good floors, to have doors or gates in good condition, to make good feeding arrangements, or working in semi-darkness when daylight might be obtained, represent types of wastage. But when there is no such waste high amounts of labour may still be used and the return per hour of labour may be relatively low. An illustration of the elaboration of labour leading to intensity of application may be found in the long continued bucket-feeding of calves by women on some farms, although this tends to to improve the quality of calves the improvement may not be in proportion to the extra labour given.

The main consideration for the farmer may then be whether any other enterprise could be added to the farm, or whether one or more enterprises could be increased without diminishing others, or whether one or more enterprises can be increased at the expense of others, and the income per hour of labour and total income thereby increased.

There are difficult questions but there cannot be any doubt on these points :—

(1) That many small farms tend to be "overstocked" with labour.

(2) That there is some waste of labour, *i.e.*, use in poor forms or by poor methods.

(3) That there is extensive use of labour due to lack of alternative uses to those in which it is now applied, or due to insufficient consideration of alternative uses.

A considerable proportion of the labour of attendance on livestock on Welsh farms is provided by the women. The care of poultry and the rearing and feeding of pigs is almost entirely undertaken by them, while much of the work of milking and the care of the dairy cows and calf rearing is done in addition, on the smaller farms. There is now little work for which women are required in the arable fields. The reaper and the self-binder have relieved the women of tasks of drudgery in the corn harvest,

and various machines for hay harvesting have done away almost entirely with the need of hand labour in that field. There are exceptions to these statements to be found on small holdings; but, in general, women on farms attend only to the lighter tasks in connection with the livestock. Even this class of work tends at present to be done more and more by man labour, as suitable woman servants become increasingly difficult to obtain in some districts and less women are employed on farms.

A study of the conditions of labour organization on a group of sixteen Welsh mixed farms throws considerable light on the problems of management and use of labour on small farms, where there is little or no specialisation of labour for specific tasks, and a complex network of enterprises to be dovetailed in the plan of labour organization. The general results of this study emphasized particularly the great variety of conditions that are found on farms which to all outward appearances are fairly similar. Farms of almost equal size and with identical farming systems show widely different use of labour inside the farm organization. Some farms use labour exhaustively in growing arable crops while others attend more to intensive attendance on stock and use woman labour lavishly, and possibly wastefully for this purpose. Statements of the labour requirements of different tasks on these holdings vary widely from farm to farm. Part of these variations are connected with the nature of the soil, and the layout of land and buildings, but they are mainly expressions of the variety of management or can be connected with the individuality of the farmer.

In the statements of the actual labour time devoted to each class of stock on these farms, presented below, there is not and cannot be any general assessment of efficiency in labour management except in a very preliminary manner. Requirements of stock are heavy on some farms compared with others, but then the type of stock produced may more than justify such expenditure. Only a careful analysis of the incomes on a comparable basis would provide the data for such assessment. Again, it is difficult to use strict economic tests with complex units such as the Welsh family farm where the "home" and the "farm" cannot be dissociated. On the other hand, however, there is undoubtedly poor and wasteful management of labour—especially unpaid family labour, as there is much poor and ineffective farming in Wales, and a preliminary statement of the basic facts of labour organization is necessary before any close analysis is possible.

Table 1 below shows the distribution of the holdings studied according to total acreage, and the number of each class of livestock carried.

TABLE I.

Acreage of farms and livestock carried.

Farm No.	*Acreage (cultivated area).*	*Per cent. grass.*	*Work horses.*	*Dairy† cows.*	*Breeding ewes.*	*Total pigs.*	*Total fowls.*
1	48	85	3	9	30	3	106
2	60	77	4	5	15	5	44
3	68	69	3	14	—	9	98
4	89	66	4	10	—	11	158
5	108	80	4	12	16	8	213
6	113	84	3	13	83	8	55
7	121	74	5	13	28	11	90
8	144	71	6	14	40	12	113
9	147	68	6	11	37	13	122
10	167	82	5	15	89	7	62
11	191	82	4	21	46	25	100
12	196	76	7	24	22	19	80
13	320	82	6	33	224	49	75
14*	128	82	5	19	218	9	133
15*	127	86	4	10	319	6	44
16*	89	70	4	11	391	1	32
Average	132	78	4·5	14	—	12	95

* These three are highland sheep farms, and the total area, including rough grazings, covers 441, 455, and 507 acres respectively.

† Including dry cows, heifers in-calf, and bulls.

The average size of the farms in the group is greater than than the average of all Welsh farms, but that is almost necessarily so in any study of labour conditions. Very small holdings do not lend themselves to any but the most general analysis of organization of labour. With a study using detail weekly time sheets of each worker on the farm it was necessary to choose fairly large holdings where the voluntary co-operation of the farmers was forthcoming, and the data likely to be sufficiently accurate and trustworthy for analysis.

The distribution of labour time over the different farm departments varies from farm to farm, and a summary of this feature is given in Table 2 below. On the whole, however, nearly half the total labour time is used in attendance on livestock. The actual proportion ranges from 60 per cent. on the smallest farm, to about 30 per cent. on a medium-sized farm with a heavy sheep complement. The greater part of labour on livestock is supplied in the winter and spring months, when the

cattle and horses are indoors, and extra labour is required at calving and lambing time, both of which occur mainly in the spring on Welsh farms. The work on crops, both arable and grass comes mainly from March to October, when livestock are outdoors, and when the main tasks are milking and calf rearing,

TABLE II.

Percentage distribution of manual labour time on Welsh farms.

Farm No.	*Livestock attendance.*	*Land work.*	*General establishment labour.*	*Miscellaneous.*	*Total.*
1	60.1	34.0	3.9	2.0	100
2	53.3	24.2	15.6	6.9	100
3	53.2	31.8	9.9	5.1	100
4	48.5	34.8	9.1	7.6	100
5	48.6	36.6	11.8	3.0	100
6	31.7	44.3	20.9	3.1	100
7	53.8	26.8	12.7	6.7	100
8	34.4	38.6	22.0	5.0	100
9	43.5	39.0	11.9	5.6	100
10	38.3	37.8	21.1	2.8	100
11	47.7	31.8	17.3	3.2	100
12	55.0	28.1	11.6	5.3	100
13	53.9	33.8	10.8	1.5	100
14	52.0	29.2	13.7	5.1	100
15	49.3	30.9	15.4	4.4	100
16	48.1	32.2	18.8	0.9	100
Average ...	48.7	33.1	14.2	4.0	100

with the ordinary routine duties in connection with pigs and poultry. A great part of this summer work with all classes of livestock except sheep is done on many farms by the women, and the following table showing the proportion of the total working time provided by the women, illustrates this point.

TABLE III

Percentage of woman labour time to total. Thirteen farms.

Farm No.	*Per cent. woman labour.*	*Farm No.*	*Per cent. woman labour.*
2	35	9	16
3	29	10	7
4	18	11	3
5	7	12	19
7	31	13	7
8	14	14	4
		16	19

Average for farms under 150 acres = 17 per cent.
Average for farms over 150 acres = 9 per cent.
Average for all farms = 13 per cent.

The data on two of the farms in the group of sixteen studied was not on a comparable basis on this point, while on another farm there was no farm work done by the women. Taking the average given above for the proportion of women labour time to total, it can be estimated that women undertake more than a quarter of the total work on general livestock on these farms. The proportion is much higher if horses are excluded from the complement of livestock.

Labour requirements of Livestock Classes.

There are many difficulties which arise in any attempt to measure the actual labour time used in attendance on different classes of livestock on small farms. In the first place the daily tasks are numerous, each taking a short time, and this complicates the work of recording and increases the possibilities of error. Secondly, the livestock on small farms is generally arranged in several independent sections, each housed separately, although belonging to the same class of stock. The cattle section illustrates this point. The dairy cows are generally separate from the young cattle, although it is impracticable to separate the labour on calves from that on the cows. The yearlings, and the two-year-olds are generally housed separately, and there may be several small batches of these, especially on farms with inadequate buildings. Much of the work of preparing food is done in common for all stock, and the time to be charged to each class cannot be separately measured. In the analysis of this data the labour time spent on each class of stock—horses, cattle, sheep, pigs and poultry—has been kept separate, but no distinction was possible between the different kinds within each class. This should be borne in mind in interpreting the requirements of labour time outlined below broadly for each class.

Horses.

The highest paid man on Welsh farms is generally the horseman, and he undertakes most of the work in attendance on horses. The details of this work need not be enumerated here, but it is important to note that, on most farms in Wales, the working horses are housed indoors throughout the winter, and even the young horses are in most cases given some dry food and shelter in those months. There has been a criticism of Welsh farmers that too much attention has been given to the horses, and too little to the cattle. It has certainly been true of the past that on many farms the best labour was used each morning in attending meticulously to the horses,

while rather inferior labour attended cursorily to the cattle. This criticism has less force at the moment, when the horse trade has declined and comparatively little interest is taken in breeding and rearing of horses for sale. On small farms the problem of maintenance of horses is one of the most serious. There is comparatively little work for them to do on these grass farms, and yet in many areas they have to be housed in the winter, consuming the best oats, and hay products of the farm. The following table sets out the actual number of hours used in attendance on all horses on individual farms on the average of two years.

TABLE IV.

Manual labour requirements of horses.

Farm No.	*Total* horses.*	*Total labour time.*	*Labour hours per horse.*	*Horse labour as % of total livestock labour*
1	3	529	176	13.9
2	1	337	84	7.7
3	4	503	126	9.9
4	4	367	92	9.9
5	5	957	191	17.2
6	4	841	210	27.7
7	8	721	90	10.8
8	8	577	72	16.7
9	9	619	69	17.7
10	9	790	88	16.8
11	7	216	31	5.0
12	12	660	55	7.4
13	10	1,520	152	11.2
14	6	757	126	10.2
15	3	494	165	11.2
16	6	524	87	8.8
Average ...	6—7	650	102	11.8

* For number of working horses see Table I.

The extreme variations from farm to farm are again apparent in this table. Farm No. 11 is an example of a grass milk-selling farm in South Wales, where horses are maintained as cheaply as possible for the light work available. There is none of the elaborate attention given to horses on this farm that is evident from the results of farms 5 and 13. Both of these attend with all care to the horses during the winter months, and the figures of labour used in attendance are unduly high. There are no records of time requirements on work horses alone, but if it is assumed from experience that young horses require approximately fifty hours each per annum, then the figure for

a work horse on the average of these farms will be about 185 hours.

It is interesting to compare the number of manual hours used in attendance on horses with the actual number of hours of work done by horses on the farms. This gives some indication of costs and returns of working horses, and points particularly to the difficulty of maintaining horses on small grass farms.

TABLE V.

Manual labour in horse attendance in relation to horse work done.

Farm No.	*Horse work done (hours per horse).*	*Horse work per hour of attendance labour (hours).*
1	376	2.1
2	478	5.7
3	814	4.8
4	775	8.5
5	615	2.6
6	737	2.6
7	819	5.6
8	764	8.0
9	691	6.7
10	873	5.5
11	747	13.8
12	756	8.1
13	945	3.7
14	905	6.0
15	620	5.0
16	875	6.7
Average ...	736	5.1

The peculiar difficulty of the small holding is well illustrated on farm No. 1 where little more than two hours of work is provided by horses for each man hour of labour in attendance on horses.

Cattle.

On most of these mixed farms the dairy herd holds a position of particular importance. A great part of the income of the farm is derived from the sale of store, fat and dairy cattle and the sale of surplus dairy products, and the dairy herd is the foundation of stock rearing and the production of milk and milk products for sale. Most of the farms studied here rear store stock for sale at eighteen months or two years old, and the surplus milk is made into butter. The skim or separated milk is fed mainly to calves, but it also plays an important part in the rearing and feeding of pigs. The work of attendance on

cattle is heavy in the winter when almost all beasts are feeding indoors, but is almost entirely confined to milking and the hand rearing of calves in the summer. For the most part the cows dry off in the winter, to calve in the early spring. But even so, they are maintained indoors and the work of attendance is very little less than if a fairly high proportion of winter milk were produced.

A general criticism of many Welsh farms, and more especially the smaller holdings, would be that the lay-out of the holdings and the arrangement of the hay and corn yards, and the manure heap, is poor and ill-designed for saving of labour and elimination of drudgery. Far too many of the young stock are housed in awkward hutches far away from the barn, giving unnecessary labour time in feeding and general care, and often not providing adequate light and ventilation. The same criticisms can be levelled against many of the double row cow byres which tend to be cramped and which provide neither light or sufficient cubic space for health. All these factors influence the labour time used in attendance on livestock in addition to retarding growth and adding to the practical difficulties of the farm. In many cases the situation could be improved, and the lay-out of buildings, in relation to the manure heap, the barn, and rickyards considerably amended to save time and unnecessary exertion. There is little doubt that the fact that the labour of the family can be used freely, and particularly the labour of the women, accounts to some extent for the slowness of improvement in this direction.

The actual labour time used in attendance on cattle shown in the table below, covers work in connection with the dairy herd, including milking and subsequent use of milk, as well as all the work of feeding and attendance on all classes of young stock.

The highest requirement is shown by farm No. 7, at 133 hours per head. This is a milk selling farm, and a proportion of the hours spent in delivery of milk is included in the total. The other high figures are obtained on the smaller farms of the mixed type.

The usual figure of the labour requirement of a dairy cow is around 200 hours per annum, but most of these results have been obtained on milk selling farms, so that holdings in this study are not quite comparable. If, however, this figure is taken for the cows in milk (treating heifers in calf, dry cows and bulls with other cattle) to make it comparable with cost of labour figures for milking herds, then the labour requirement

TABLE VI.

Manual labour requirements of cattle.

Farm No.	*Number dairy cows.*	*Number other cattle.*	*Total cattle.*	*Total hours.*	*Hours per head.*	*Cattle manual labour as per cent. of total livestock labour.*
1	9	15	24	2,182	91	57.5
2	5	14	19	1,653	87	37.7
3	14	12	26	2,876	111	56.4
4	10	22	32	3,070	96	82.8
5	12	28	40	3,421	85	62.2
6	13	32	45	2,086	46	69.8
7	13	17	30	3,990	133	60.3
8	14	23	37	1,833	50	52.9
9	11	20	31	2,030	65	57.6
10	15	25	40	2,427	61	52.0
11	21	39	60	3,490	58	80.7
12	24	50	74	6,254	85	69.2
13	33	73	106	8,016	76	58.7
14	19	41	60	4,475	75	59.4
15	10	49	59	2,448	41	55.8
16	11	25	36	3,345	93	56.0
Average ...	14	30	44	3,349	75	60.5

per head of young cattle is about 40 hours. Or alternately if 40 hours per head is allowed for the young cattle, and the heifers and bulls are included in the complete dairy herd, then the requirement per head in the dairy herd in this sample works out aι around 150 hours.

The summary below giving the monthly variation in hours of attendance labour on all cattle, shows how the work of

Monthly variation in labour on cattle.

	Average hours per week.		*Average hours per week.*
January ...	1,357	July ...	782
February ...	1,317	August ...	782
March ...	1,247	September ...	746
April ...	1,206	October ...	815
May ...	899	November ...	1,052
June ...	863	December ...	1,312

feeding and maintenance in the winter period compares with the work of milking, and calf rearing in the summer time.

Women provide a high proportion of the labour used in summer while much of the general winter attendance is the work of the regular male staff.

Labour requirements of Sheep, Pigs, and Poultry.

It is obvious that from the point of view of organization of labour on the farm, the time used in general attendance on sheep presents few or no problems. Most of the actual regular work comes in the spring at lambing time, and at special intervals in summer for shearing and dipping. Conditions, however, vary widely on individual farms. Where fairly heavy Cross Bred or Down Sheep are kept on the lowlands, trough feeding is fairly general in spring, and many farms feed lambs and yearlings on roots in the winter months. Where the native sheep are kept, especially at the higher elevations, the work on actual attendance is reduced to a minimum, although there may be considerable time spent in shepherding on the more open mountain farms. The statement of actual labour time used on sheep on individual farms is as follows :—

Manual labour requirements of sheep.

Farm No.	*Number of breeding ewes.*	*Total hours.*	*Hours per ewe.*	*Sheep hours as per cent. of total livestock hours.*
1	30	333	11	8.8
2	15	370	25	8.4
5	16	137	9	2.5
7	28	658	23	10.0
8	40	293	7	8.4
9	37	334	9	9.3
10	89	1,052	12	22.5
11	46	389	9	9.0
12	22	621	28	6.9
13	224	1,148	5	8.4
14	248	1,100	4	14.5
15	319	1,156	4	26.2
16	391	1,805	5	30.2
Average ...	116	672	6	10.6

The variations on individual farms are very wide, but that is only to be expected in a group of farms representing many types of sheep management. The average is unduly weighted by the large native flocks of the mountain farms Numbers 14—

16 bringing about a requirement which is obviously too low for the smaller flocks of the lowland farms. An estimate of from 7—10 hours per ewe is probably representative on these holdings, while between two and four hours would be adequate on the upland farms. When the whole flock is considered, including all categories of sheep and lambs, the weighted average requirement per head for the group is around 8½ hours.

Monthly distribution of manual labour on sheep.

	Average hours per week.		*Average hours per week.*
January ...	151	July ...	210
February ...	187	August ...	195
March ...	242	September ...	166
April ...	223	October ...	120
May ...	160	November ...	113
June ...	275	December ...	137

This monthly schedule brings out very clearly the demand for labour by sheep at special seasons, notably at shearing and dipping times in the summer months.

Information on amounts of labour utilised on attendance on pigs and poultry on farms, is more difficult to collect. Because these are generally two minor branches of activity, little attention is given by the management to the labour used on the routine tasks, which are mainly the prerogative of the women. The complete picture, however, is not available unless the time used in attendance on the smaller livestock is measured, and analysed in relation to the size of the farm and the pigs and poultry units. On most of these mixed farms, one or more breeding sows are kept, and the pigs may be sold as weaners or fed for pork or bacon according to circumstances both inside and outside the farm. There is such diversity in practice in this respect that it is impossible to obtain any reliable measure to indicate the importance of the enterprise on individual farms. In the table below only the number of breeding sows is given, but some indication of the scope of the pigs branch will be obtained from the total hours of labour used in attendance.

Farm No. 11 is an example of reduction in labour time by keeping the sows in a paddock with improvised sheds, using as little labour as possible.

Of the total livestock labour over the group of farms, the time spent on poultry only amounts to about 6 per cent. Here

again there is the difficulty of getting any satisfactory unit of poultry, to which to relate the labour used, for measurement. The farm flock consists of a conglomeration of birds including

Manual labour requirements of pigs.

Farm No.	*Breeding sows.*	*Total hours.*	*Labour on pigs as per cent. of total livestock labour.*
1	—	596	15.7
2	1	1,278	28.9
3	2	868	17.1
4	2	270	7.3
5	2	630	12.3
7	2	312	4.7
8	2	493	14.1
9	2	336	9.3
10	1	186	3.9
11	4	137	3.1
12	4	1,026	11.4
13	3	2,957	21.7
14	2	610	8.1
15	1	300	6.9
16	—	112	1.9
Average ...	2	674	11.1

chickens, and fowls for all purposes. Using the grand total of all birds recorded on these farms, the labour used per bird is calculated to be about three hours per annum, but again with wide variations between farms, expressing mainly the difference in management between the barn door fowl and the specialist hen.

General.

The actual figures shown in the tables showing the time utilised with each different class of stock on these farms offer some guide to the study of labour conditions on Welsh farms. Judged by standards of what ought to be, they undoubtedly suggest unnecessarily high requirements leading to high real costs of production. But it has been emphasised already that no such conclusions are justified, without considerations of real output and an appreciation of the circumstances of individual farms. The high variations, in all the groups of figures, shown by individual farms is in accordance with the facts of farm practice, and these arise out of real differences inside the farming system, the available labour supply, and conditions of layout of buildings and land as well as the size of farm.

As the study is mainly concerned with mixed livestock farms of the type frequently found in Wales especially in the valleys of the Western Counties, it would be useful to find cases in this sample which give fairly typical normal results for this class of holding. Two farms, both situated in Cardiganshire, Numbers 8 and 9 can be taken as holdings representative of this type. Both are about 150 acres in size, with medium quality land, most of which is cultivable. Most of the land on both farms is managed on the long rotation, with about four years of arable cropping followed by long leys of from four to ten years. The system of mixed farming is very similar in the two cases although the land is heavier in Case 8 than Case 9, and both are well managed by farmers of thirty years standing, of ability above the average who have made good living incomes. The figures presented for these holdings are reliable and can be taken to represent this class of holding in Wales much better than the average of conditions on sixteen farms. The average of a sample of farms of varying sizes, and conditions of management (although they may be classed as mixed farms) is unduly influenced by the abnormal, especially when the number of farms is hardly sufficient to ensure adequate correction for such influences.

FINANCIAL ASPECTS OF GLASSHOUSE PRODUCTION.

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Most people who are in close contact with agriculture in Wales at present are impressed with the need of serious consideration of the future development of the industry in our own country. Changes in farming practice are always occurring and thinking farmers are constantly seeking fresh opportunities of utilisation of capital and labour on their farms. Some of these changes occur in the system of management of existing enterprises; better breeding, feeding, and handling of livestock to suit the needs of the market, while others seek to develop a new combination of enterprises or tend towards special development of one enterprise. Although these conscious changes undertaken by farmers individually in response mainly to the opportunities of the market are slowly evolved, they become significant when measured collectively over a period of time. The growth of the

poultry industry in both England and Wales during the last decade is an example of the changes which take place in agriculture and the comparative facility with which farmers adapt themselves to new circumstances.

It is not difficult to foresee a somewhat similar movement in Wales towards production of more intensive horticultural crops and glasshouse produce in the near future. This development has already begun, although the official statistics available give but little indication of its significance. Welsh farmers favourably situated with regard to land, layout, and the consuming markets, are realising the probable limitations in the future of trade in the staple livestock branches of Welsh farming. Our Empire countries are fast becoming more potent competitors in the meat markets and the market for dairy products in this coutry, so that some Welsh farmers who have facilities are considering possibilities of production of perishable bulky products in which the situation with reference to the market is of prime importance. This does not mean that the natural advantages of large areas of Wales for grass farming, producing principally cattle and sheep, will not be exploited or that livestock husbandry will or can be superseded. But there are some areas of suitable soil favourably situated which will undoubtedly be used for intensive farming, mainly with horticultural crops and specialist livestock enterprises, in the natural course of events.

Production of horticultural crops means a high output of food per acre and more employment of labour per acre than almost any other form of crop husbandry. This latter feature is important at the present time when there is a surplus of labour in most industries, and a general desire that some of the surplus may be employed in the cultivation of the land. But apart from the possible absorption of surplus labour from other industries there is the more important question of utilising the labour and capital available in the farming industry itself. Each year a number of farmers' sons have to seek employment and the use of some capital outside the farming industry. The number of farms is definitely limited, and only a proportion of the male members of farm families can expect to enter the industry in its present form. In the past there have been opportunities for the sons of farmers in Wales to leave the industry, take with them some farm capital, and enter other productive or distributive businesses. It is desirable, however, to retain these men and their capital accumulated out of farm savings; and small holdings farmed intensively offer one possible solution to

the problem. Unfortunately, farmers brought up in close contact with livestock on grass farms take but slowly to intensive arable cultivation. And sons reared on large livestock farms are convinced only with difficulty that an intensive poultry holding or a few acres devoted to glasshouse produce is in every way as " big " as the ordinary mixed farm. In the last five years, however, the attitude of Welsh farmers in general towards poultry has changed significantly, and there are now numerous examples of farmers paying as much attention to the hen as to the dairy cow. It is reasonable to expect that farming opinion in many areas will show a similar movement towards serious study of the commercial possibilities of horticultural and glasshouse produce, either as adjuncts to existing farms or as basis for successful small family holdings. It might well be suggested that the education authorities should take a more definite part in assisting farmers and more particularly their sons to understand and appreciate the possibilities of this type of enterprise and the qualities which it requires.

The justification of the foregoing remarks lies in the need for hastening the change in attitude towards intensive culture amongst the farming community and leaders of opinion in Wales. There is even now need of more dissemination of knowledge of the technique of intensive plant culture and also of the economic aspects of production and marketing of the crops.

Capital and Labour.

It is a feature of intensive production of produce under glass, that a comparatively large amount of capital is concentrated on a small area of land. In some areas the land used for these purposes is comparatively cheap, in that most of the surrounding land is used for ordinary agricultural purposes connected with either crops or stock. But in general, glasshouse production has been concentrated in areas close to the centres of consumption, and the price of the land has been high because its valuation approximated to building-site value in these areas. It was natural, therefore, to expect high concentration of capital and labour on a small area, and the greatest possible production per acre of land. But where glasshouse production is taken up in a typically rural, but otherwise suitable area, the value and cost of the land is less and high concentration of capital may not be so necessary. Other factors, of course, affect the situation, such as the need for concentration of glasshouses to provide economical units for heating and for arrangement of labour time. But cultivation and handling of glasshouse produce is a specialist business, and conditions of production

are more comparable to those in a large workshop or factory than the farm, so there seems little prospect of increasing output under glass in Wales by adding subsidiary units to general farms. Most probably there will have to be concentration in specialised units, using ample capital and adequate knowledge of technique of production and marketing. These units need not, however, be on a large scale and a family basis is likely to be as successful in this as in other fields of farm production.

The actual amount of capital necessary in a glasshouse unit depends to some extent on the combination of produce raised; on the methods of building; transport; cost of equipment; cost of roads, etc., which are peculiar to each site. The cost of equipment will in general be greater where a large number of different crops are cultivated than where a single product is raised. Different products require slightly different heating conditions and where a glasshouse is used for two or more crops, the selection of type of house becomes a matter of compromise or of adaptation to the purpose. There are other items of subsidiary equipment necessary for each product which add necessarily to the total capital cost. The estimates for fitting a glasshouse unit for tomato growing range from about £2.500 to about £4,000 per acre. This assumes the greatest possible concentration of glass, and includes the cost of the houses, heating equipment, roads and paths, water supply and incidental implements and machinery. It is obvious that estimates of capital cost can only be indicative and that the actual investment will vary widely according to the actual circumstances of each unit. Provision of road vehicles for delivery of produce is another considerable addition to capital cost in areas where railway facilities are not adequate for efficient marketing, or where the trade is localised and produce is transported direct from producer to retailer. The main point is that there is high concentration of capital over a small area of land and that a high proportion of receipts from the sale of produce has to be devoted to covering depreciation and interest charges.

The amount of labour employed per acre in glasshouse production varies according to the combination of crops grown and the methods of marketing. But whatever the individual circumstances of the glasshouse unit, there must be comparatively high concentration of labour. The work of cultivation and treatment of the crops is specialised and delicate and this necessitates the intensive application of trained labour. For tomato growing it is estimated that an acre of glass provides work for about five to seven persons over the year. With only one product

there is some seasonality in labour requirements, and extra hands are taken on in the spring and summer months. Most units, however, get over the difficulty by combining some winter crop or crops with the staple tomatoes or cucumbers for summer production.

Costs and Returns.

In the absence of comprehensive data covering glasshouse units using different combinations of crops, or a sample of units with similar conditions of production and marketing, the summary of figures below from three typical examples will be used to indicate the broad economic features of the business. It is hardly necessary to point out here that costs and returns show wide variations in practice according to the special circumstances of production and marketing of each unit and the skill and efficiency of the management. But the figures for individual units will only vary in detail and the fluctuations will be either above or below what is here presented as a representative case. The figures in Case A. indicate the cost and returns of tomato growing in recent years. The unit studied consists of several acres of glass devoted almost entirely to tomatoes and cucumbers. By careful accounting the owner has worked out the following cost statement per acre for tomatoes from his actual experience during the past two years.

Cost and Returns per acre of tomatoes. Case " A."

Items.	*Per Acre.*	*% of Total.*	*Per lb.*
	£		*d.*
Labour	550	32.9	1.47
Fuel	250	14.9	0.67
Manure	45	2.8	0.12
Sundry supplies	44	2.7	0.12
Packing and Carriage	170	10.2	0.46
Market expenses	157	9.4	0.42
Total Direct Charges	1,216	72.9	3.26
Depreciation	200	12.0	0.54
Rent and Interest	193	11.5	0.51
General Sundries	60	3.6	0.16
Total Costs	£1,669	100.0	4.47
Gross Receipts	£1,960		5.25
Net Surplus	£291		0.78

Assuming a total yield of tomatoes of 40 tons of saleable produce per acre, which is probably on the high side for average conditions, the cost per pound comes to approximately 4½d. Direct charges account for rather less than three quarters of the total costs, and overheads for about 27 per cent. of the total. Costs of labour and fuel are noticeably prominent, but it is doubtful whether most nurseries are able to work as cheaply as these figures indicate. The amounts paid for transport and expenses of marketing, making together nearly a fifth of the total costs, illustrate the importance of marketing costs with a bulky and perishable commodity which has to be carefully packed and sold almost daily during the season. In the case cited here all the produce was sold direct through commission salesmen at a central market, and producers able to sell direct to retailers would reduce such charges. The figure of £291 net surplus shown for this unit for the year is the earnings of management, because all interest and capital charges have been included in the cost schedule. The total earnings of the owner and his capital amount to £484. The actual amount of surplus available in any year depends partly on the level of prices of the product throughout the season, and partly on the distribution and total yield of the crop. The more specialised and concentrated the range of production becomes, the greater the risk of serious loss and fluctuation in yield and in cash returns so that the figure shown above for available surplus must contain some provision for the risks taken.

Case " B " illustrates the costs and returns in a smaller unit, where both tomatoes and cucumbers are grown. The unit was first erected to produce tomatoes mainly, with cucumbers as a subsidiary crop, but in recent years it has been found more profitable to increase the proportion of the latter and to add chrysanthemums as a winter crop on a small scale. This cost statement (which is an average of two years—1930 and 1931) therefore gives the main items of cost in a nursery producing a combination of products.

The itemised schedule " B " differs somewhat from "A" discussed above. Costs of carriage and market commission have been deducted before arriving at the figure of total sales here shown. Interest charge on the capital invested is also excluded, but actual charges on a small bank overdraft, and depreciation of plant, have been entered in cost. The total figures of cost and returns for "A" and " B " are not therefore on a comparable basis. The total costs in the latter are appreciably heavier, while the sales are only very little greater than in the

former. The surplus available in Case " B " after meeting all scheduled charges, only amounts to £187 per acre, and this is obviously insufficient to meet reasonable interest charges on £4,000 of fixed capital and some return for management of the business. The two examples may be said to illustrate one case where a reasonable living was provided and the other where in the average of two years there was little or nothing available for the management, after all legitimate charges had been met. In comparing the list of items shown for Case " B " where three or more products may be grown, with "A" where only tomatoes are grown, the higher costs of labour and fuel in the former should be specially noted.

Cost schedule per acre. Case " B."

	Per Acre.	*% of Total.*
	£	
Labour	648	38.1
Fuel	434	25.7
Water	46	2.7
Fertiliser and Seeds	140	8.3
Steaming	72	4.3
Repairs and Supplies	41	2.4
Cartage and Packing	96	5.7
Sundries	26	1.5
Bank Charges and Depreciation ...	190	11.3
Total	£1,688	100.0
Sales (less Commission charges and carriage)	1,875	
Surplus	£187	

The third case " C " is quoted by permission of the Hertfordshire Farm Institute, St. Albans, and the figures are taken from the published accounts for the seasons 1931 and 1932. The unit consists of about 1¼ acres of glass, used mainly for tomatoes and cucumbers and to a small extent for flowers.

Costs and Returns per acre. Case " C."

	1931	*1932*
	£	£
Labour	597	667
Fuel	468	478
Fertilisers	34	39
Packing material, carriage, etc.	222	241
Repairs	30	51
Sundry supplies and fees	160	107
Rates and Taxes	42	43
Depreciation (Loan Service Charges) ...	156	159
Interest charges	287	280
Total charges	1,946	2,015
Sales of produce	1,868	2,265
	Deficit 78	Surplus 250

Total figure of sales was made up as follows in the two seasons.

	1931	*1932*
	£	£
Tomatoes	1,449	1,722
Cucumbers	347	350
Chrysanthemums	26	71
Carnations and other flowers	10	89
Lettuces, marrows, etc.	12	13
Miscellaneous	24	20
Total	1,868	2,265

The items in cost in case " C " compare very well with those shown above for units " A " and " B ", but this unit was only erected in 1930 so that no significance can be attached to any figure of profit or loss. The broad details of cost and returns are, however, instructive.

General.

The three cases here examined throw some light on the nature of intensive glasshouse production, and the opportunity it offers in this country for employment of labour and capital. In view of the fiscal policy of this country in general and the import duties on most forms of glasshouse produce in particular there seems to be considerable scope for development of the industry in local units. It is not anticipated that any district in Wales may develop a large specialised glasshouse area, but many small units have already been established outside the consuming centres, and this movement must increase. With perishable products like tomatoes the grower situated near the final consuming market holds a great advantage over foreign competitors and even over producers in this country who have first to pass the produce through a central market, from whence it must be transported long distances by road or rail to its final destination. The grower near the consuming market saves transport and handling charges on bulky produce and is able to maintain freshness and bloom right to the consumer's door. In practically all markets there is a readiness on the part of consumers to show a slight preference in price for the perishable product which is grown locally. Even if costs of production of the crops tend to be higher in the small local units, as compared with the large specialised nurseries, this is more than made up from savings in transport and handling and the better prices realised.

The information on capital and labour requirements of glasshouse units given above rather suggests that the industry is only open to those with abundant capital resources. This is mainly

because all the figures have been expressed on the basis of an acre of land for the purposes of measurement, and it should be stressed that a highly specialised industry like glasshouse culture is particularly suited to small units where personal attention can be devoted to the technique of the production and marketing.

The tradition of family farming in Wales can very well be continued in glasshouse culture, and both the capital and labour resources of the whole family can easily be utilised. Part of the work is seasonal, and falls in the summer time when the children can be most helpful, and most of the work during the season is light and clean. A glasshouse unit managed by a family used mainly for tomatoes, could consist of about six houses 15 feet by 185 feet on half an acre of land, and the whole could be served by one double boiler heating set. The capital required would be from £1,500—£2,000 in total and it would provide wholetime work for one man and a lad, with considerable seasonal work for other members of the family and possibly some casual labour. This unit should produce, under favourable conditions, from 15 to 20 tons of crop annually, and if the market were properly served there should be no great difficulty in disposing of the produce. Costs of operation would follow the lines illustrated above for Case "A" except that labour costs would not be stated, but the earnings of the family would be revealed in the surplus available after meeting direct charges. At this stage it is not possible accurately to assess the probable surplus available to a family unit, because the actual amount would obviously vary with the efficiency of production and the opportunities for marketing. But having regard to present prices of glasshouse produce and probable trends in consumption and demand in this country there is every reason to believe that this form of enterprise would offer a living at least comparable to that obtainable in most other branches of the farming industry.

THE FUTURE OF CO-OPERATIVE MARKETING OF FARM PRODUCE IN WALES.

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In the recent history of co-operative marketing in Wales there are no clear outlines of progressive development or even

of decline. Experiences have been varied, and results of efforts good, bad and indifferent. Development has been erratic and there is no sign of co-ordination of effort, or of the formulation of any general policy for the movement. Quite frequently, it appears, co-operative marketing has been advocated as a solution of the problem of marketing produce which has been otherwise unmarketable. Where the demand has been good and the farmers had no difficulty in finding purchasers for their products the ordinary channels of trade have been used, and although they may not have given entire satisfaction there has not been any great demand for an alternative system. But in times of general economic stress or of poor demand there is a tendency to turn to co-operative organisation. Thus the majority of ventures have been floated under the most difficult circumstances, when capital was scarce, and produce relatively unsaleable.

This experience of Wales is not unique, for co-operative enterprises often have been the "children of necessity." Quite commonly, in fact, the parents of co-operation have been economic and social idealism on one side and economic depression on the other. The union of these has produced many of the co-operative movements of the world. Occasionally, this union has been inspired by patriotic feeling, by ideas and efforts in planning for national development. Only rarely, if ever, has any co-operative movement arisen as a result of economic planning on a colder rational basis without the pressure of poverty or the stimulus of patriotism. There have been some cases of growth of co-operation, more particularly for credit purposes, inspired if not imposed by superior administrators, where the element of rational planning has seemed to be dominant, yet even here the administrators have been concerned with a fundamental poverty.

The elements of poor financial returns, of fear if not realisation of poverty, and idealism, have been evident in the co-operative movement of Wales. The idealism was strong in the earlier years of this century when large numbers of the requisite societies and some of the marketing societies which have failed were formed. It rose again under special stimulus in the years immediately following the war, but at this period it was not so widespread amongst farmers as in the earlier period. The possible connection between agricultural co-operation and patriotic effort for national development has often been discussed but so far without any obvious effect. The more recent cases of co-operative organisation have sprung from economic trouble and resorting to the only or the best known method of finding an alternative system of handling produce.

The critic of agricultural co-operation may find plenty of occasions for his attitudes and views in the history of the Welsh movement, and the apologist may reply, but it is always difficult to bring their points of view together and develop a constructive policy. Keen enthusiasm has often overcome cynical criticism, but enthusiasm has not always been infectious or alone sufficient for success, and the views of critics have been strengthened again and again. Yet in spite of failure, recurring antipathy, even cynicism, farmers return to co-operation in the search for a solution of their marketing problems. But spasmodic developments do not imply a general acceptance of the principle of co-operative marketing : they represent merely the application of the principle to specific problems which at the time present great difficulties, and at no time has the principle been applied to more than a very small part of total production.

Such marketing of produce as has been done co-operatively has been conducted on the basis of two different forms of business organisation. Firstly, with the stabilisation of requisite societies throughout the country an attempt has been made to undertake the marketing of farm produce as a branch of the requisite movement. Secondly, where difficulty has been encountered in the marketing of any specific agricultural product special co-operative organisations have been set up to deal with that individual product. A more recent development, however, has been for several requisite societies to assist in the organisation and financing of a special co-operative processing and marketing organisation to deal with one product which has been causing the individual societies some considerable difficulty.

Whether the development of marketing business by a requisite society is the ideal method to be adopted is open to some doubt although it has many advantages. It is a development which is often forced upon the requisite societies in order to retain trade; for many farmers find it advantageous to sell their products at the same time as they make essential purchases. But in such cases co-operative marketing is merely a " side-line " and is invariably handled by the staff of the requisite business and therefore is subsidiary to that part of the trade. It is hardly likely that under such circumstances the marketing of farm products will receive the attention and development it really requires. Provided the produce section does what it was intended to do, i.e. to maintain the requisite business, the management are perfectly satisfied. Where the marketing side does develop it may become necessary to appoint a special manager and the tendency is towards dual control; commonly an unsatisfactory arrangement.

Co-operative marketing in Denmark has developed mainly on the basis of separate organisations thus necessitating a farmer taking out a membership in several societies according to the number of products he wishes to sell as well as being a member of another society if he wishes to purchase his requirements co-operatively. But it is invariably easier in this country to link up a marketing organsation to a co-operative requisite society than to establish a new organisation. A membership is already at hand, an organisation with a committee of management and in many cases some or all the necessary capital and buildings are available without any further demands upon the members. In fact, the local society with its connections and experience is in a far better position to estimate the necessity for such a marketing organisation and the probable loyalty of the members to it. Experience in Wales of a marketing branch being attached to the more important requisite trading businesses is varied in the extreme. The statement below shows the commodities dealt with in a number of the requisite societies together with the total sales for the trading year 1931.

Commodity.	*Number of Societies.*	*Total Sales.*[1]
		£
Milk ...	1	20,666
Eggs ...	4	17,313
Other dairy produce (mainly butter)	3	15,349
Wool ...	2	1,129
Poultry ...	1	500
Grain ...	2	303

The society selling milk might conceivably be classed as a dairy society as its sales of requisites, mainly feeding stuffs, amounted to slightly over £10,000. The remaining societies are predominantly requisite societies. It is difficult to estimate whether the marketing branches of these requisite businesses are profitable or not in the direct sense as their trade may be indirectly profitable although it is directly unprofitable. Accounts are not always maintained with accuracy for the separate

[1] There are more than two, probably many, societies dealing in their members' grain mainly by outright purchase but sometimes on agency terms. Purchases of grain from members are commonly omitted from accounts of produce dealt with because this grain largely serves the same purposes as grain purchased from other sources. Some purchases or agency sales of potatoes, and retail or small wholesale sales of butter and eggs, also occur without being separately recorded. Where the produce is of a type distinct from the commodities which form the main trade of the requisite societies the produce sales are usually recorded separately. Nevertheless the total of produce sales recorded does not show the real total sales.

branches of the businesses for while purchases and sales may be recorded it is not always possible accurately to apportion costs of handling. But provided the combined result is acceptable to the committee of management little notice is taken of the individual enterprises. Even where it is known that the marketing business is not directly profitable it is difficult for that society to leave it without an unfavourable reaction upon the goodwill of the requisite business.

Under such circumstances it is almost impossible for the co-operative marketing of farm products to develop satisfactorily. It is not essential, however, that the requisite movement and the marketing movement should be segregated but that each movement should be given equal consideration and that neither should be made subsidiary to the other. Each branch should be financially independent and operated independently and this is quite possible without losing or foregoing any mutual advantages which are available.

The societies organised primarily for the sale of produce must be distinguished from the produce branches of requisite societies.

Dairy societies in Wales may be classed into three distinct types or groups. The first group includes the societies which operate mainly for the sale of liquid milk. In this work each society finds that it can profitably undertake the sale of other products such as eggs, but some societies find themselves under an obligation to manufacture surplus milk. But their main business is in the liquid milk trade. There were four societies in this group in 1931, two of which were only in a small way of business and engaged entirely in the liquid milk trade. The remaining two operated subsidiary businesses, one handling eggs and other dairy produce, and the other manufacturing cheese and butter and feeding pigs with the bye products. The total sales for 1931 were :—

	Milk.	*Pigs.*	*Eggs.*	*Other dairy produce.*	*Sundries.*
	£	£	£	£	£
4 Societies	24,171	1,695	461	4,988	494

The second group includes the cheesemaking societies. There were four registered societies in Wales in 1931 but two were not operating during the year. The remaining two were also experiencing difficulty in getting the necessary milk supplies

to operate economically, this being the cause of the closing down of two other factories. The total sales of cheese during the year 1931 amounted to £1,389. The history of co-operative cheese-making societies in Wales is interesting and, in spite of their decline, is not in any way a reflection upon co-operative organization for the disposal of surplus milk. With increased competition from the liquid milk market for supplies of milk co-operative cheesemaking has declined but several societies in Wales have operated successfully and on liquidation have paid 20s. in the £. The future of these factories at the present time is uncertain and will depend upon firstly, the successful operation of a milk marketing scheme under the Agricultural Marketing Act, 1931, and secondly, the ability of these factories to fit themselves into such a scheme to secure the necessary supplies of milk for manufacturing purposes. In fact the future of all dairy societies in Wales will be affected considerably by any milk marketing scheme under the Act.

The third type is represented at the present time by only one society, which commenced operations in 1932, for the manufacture of butter. The co-operative organisation of independent creameries for the manufacture of butter has been discussed for many years, but only last year was this ideal reduced to practice. As the future of the marketing of farm butter is so uncertain, this innovation is being carefully watched by interested persons in many parts of the country as proof of its economy will stimulate extension of the system to other areas. The movement received its stimulus from an agricultural requisite society which, having found difficulty in securing a profitable outlet for farm butter previously sold, decided to set up a creamery and by the collection of cream to manufacture butter of uniform type and quality. The success of this innovation influenced the promoters of the independent factory to go forward with its work. This factory has, incidentally, relieved three other requisite societies of the responsibility of marketing farm butter for their respective members as the area of cream collection covers, more or less, the area served by those societies.

The co-operative organization of the marketing of livestock has been reviewed in a previous volume of this Journal.[2] It has been confined to setting up marts to provide facilities for the sale of livestock by auction. Six societies were in operation during 1931, and although one is in rather difficult financial

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[2] Farmers' Control of Auction Marts in Wales. Thomas Lewis, B.Sc., M.S., Vol. VII, *Welsh Journal of Agriculture.*

circumstances it is probable that sufficient support is still maintained for them to continue their activities.

In the marketing of eggs there was only one active co-operative society in 1931, although there were three registered societies. Including the requisite societies there were only five societies reporting the handling of eggs as part of their business though it is probable that many other societies are selling small quantities of eggs on behalf of their members. It is difficult to explain the general failure to develop the co-operative marketing of eggs in Wales in view of the marked expansion of the poultry industry. Whilst this branch of marketing enterprise seems to offer a good field for progressive expansion co-operative action in this direction has never been particularly successful. The only independent co-operative egg packing station in Wales operating in 1931, whilst selling eggs to the value of £10,260, did not show a profit. The station is now undergoing re-organization and it is anticipated that in view of the marked increase in supplies of eggs, it will become a profitable enterprise once again. With two defunct societies and one undergoing re-organization it cannot be said that experience in Wales has been in any way stimulating, but with English experience as an antidote it is interesting to record that farmers and co-operators still have courage and one new society was formed in 1932. At the pesent time a new society is being organized and, in addition, another requisite society is seriously considering entering the egg-packing business. With the assistance of the National Mark Egg Scheme it is hoped that these new movements will eventually become an economic success and once again prove that it is possible to co-operate effectively for the marketing of eggs. It is, however, unfortunate that an unbiassed reviewer must state that up to the present experience has not done much to further this particular branch of co-operative marketing by specialized associations, although egg marketing combined with trade in requisites appears to have been quite successful.

The application of co-operative marketing to a new product of Welsh agriculture is exemplified in the recent registration of an association of seed potato growers in North Wales. For some time experiments have been made with Welsh seed potatoes and more recently the growing of seed has been extended to farms. The successful results have proved that it is possible to produce very satisfactory seed potatoes in certain areas in North Wales and the quantity available has necessitated the formation of of some method of organized marketing. A co-operative society has been formed to take over the marketing of the seed potatoes

produced and its progress will be watched with interest. The ultimate success of this organization depends upon its ability to place these products on a market which must be cultivated and developed where previously there has not been any demand for Welsh seed potatoes.

Co-operative marketing by the requisite or the independent produce societies is, at the present time, confined to the sale of eggs and poultry, milk for the liquid milk market, the manufacture of surplus milk into butter and cheese, organization for the marketing of livestock and to a small extent, the marketing of grain, wool and seed potatoes. The history of the movement contains a variety of experience covering a variety of agricultural products.[3] There was considerable development in the war and post-war period and it is true to say that many societies were established which could never operate successfully upon a return to more normal conditions. Such experience has been responsible for the reluctance of the older farmers to enter the co-operative field again and the movement has suffered accordingly. But there now appears to be a general change in attitude of the farmers in Wales and many suggestions are made for progress in co-operative sale. The co-operative sale of horticultural produce from farms is now under serious consideration, both in North and South Wales. With the development of small holdings this movement is sure to receive a marked stimulus and the further development of horticulture will make it more or less of a necessity. The disposal of manufacturing milk in many parts of Wales is receiving serious consideration and co-operative organization is almost invariably the suggested solution of the problem. Progressive agriculturists in the Principality are now endeavouring to apply their knowledge and experience to the production of crops which have not, as yet, been recognized as typical crops for Welsh conditions. It is, however, asserted that in many parts of Wales horticulture or at least certain types of horticultural production would be a profitable enterprise and where it is proved that conditions are favourable and production is undertaken a marketing organization must be developed. There is no existing system of marketing adequate to the requirements of increased production, so there is a free field for co-operative organization. In all discussions of innovations agricultural co-operation is invariably offered as the best solution and it is probable that the future of

[3] See Agricultural Co-operation in North Wales, by J. Morgan Jones and R. Harding Wynne. Department of Agricultural Economics, U.C.W., Aberystwyth.

the movement lies in assisting the pioneers of production in several directions. But the setting up of such marketing organizations must be rapid and effective in order to secure for the agriculturists in Wales the full advantages and rewards for their courage.

The present position regarding the development of agricultural co-operative societies is dominated to a large extent by the possibilities of the application of the provisions of the Agricultural Marketing Act, 1931, by the farmers themselves to the marketing of specific products. Without troubling to trace the development of the Act itself, it may be said there is no doubt that the failure to apply co-operative principles to the marketing of agricultural products has been mainly responsible for this Act being passed. The Act undoubtedly represents one of the greatest challenges ever issued to the co-operative movement both from the point of view of producers and consumers. The future holds the possibility of forming a series of very powerful boards for regulating the marketing of a variety of individual agricultural products with a complete or partial monopoly of the home production. To persons interested in agricultural co-operation and its development the Act is of supreme interest. Schemes under the Act may be co-operative in nature if the producers of the commodity so desire but this is not an essential feature and ultimately the schemes may be far removed from the co-operative ideal.

Schemes under the Act while of a collective character will not necessarily be controlled on the co-operative principle of " one man one vote " but more generally on that of distributing basic control according to " interest ", more or less equivalent to the " share " basis of control in limited liability companies. Collectivism may be compulsory, for under certain circumstances the initial control may be exercised at the instance of a minority of producers; yet it is equally true and important that under other circumstances control may be removed by a bare majority of registered producers. Capitalisation and finance will generally be arranged also on an " interest " basis, but again financial arrangements may be compulsory. The difference between the principles of co-operation and those on which the Agricultural Marketing Act was based is largely to be found in absolute control of individuals in respect of certain marketing operations while the schemes are in force, and also in the indirect or direct power to control production. Schemes are essentially of collective and compulsory rather than of co-operative and voluntary character, even though their initial establishment depends

on the desire for collective action on the part of some producers and consent on the part of others.

Where compulsory schemes are initiated and operated under the Act the nature and scope of activities of co-operative societies must inevitably be changed. They must operate in conjunction with or under the schemes, but the nature and the forms of the functions they can fulfill will vary according to the nature of the schemes regulating the marketing of different products. In the case of farmers' co-operative societies now retailing milk, for instance, they may be ranked generally with traders as buyers of milk rather than as producers' organizations, but societies wholesaling milk may either be ranked as buyers of milk or under certain circumstances they may become the agents of the (prospective) Milk Producers' Board. On the other hand, in the case of the draft scheme for the marketing of pigs now under consideration (March, 1933) it is difficult to see any functions which farmers' co-operative societies may fulfil, but co-operative bacon factories may be either ranked as buyers of pigs or become the agents of the Pig Producers' Board for certain purposes. In general it may be expected that where compulsory schemes can be developed and operated successfully the effect must be that of limiitng at least the potential activities of farmers' co-operative societies. On the other hand, it would be a grave error to assume that the operation of such schemes will remove all need of co-operative organisations or prevent their successful operation.

Where a scheme or schemes cannot be developed, owing to the restriction placed upon their development by the necessary majorities required by the Act, the field is left entirely open for voluntary co-operation. This means the ultimate possibility of all the problems where there is only a limited unanimity of opinion on its advantages being left to voluntary co-operation and where there is a general favourable concensus of opinion to their being taken over by a scheme under the Agricultural Marketing Act.[4] In other words, the difficult and in many cases the thankless task of developing agricultural co-operation is left to co-operators working on the more difficult problems, whilst the results of their work when successful may be, and probably will be, taken over by schemes operating under the Act. As a form of compensation to the agricultural co-operative movement, Agricultural Marketing Boards are permitted, if they so desire, but they are not compelled to encourage agricultural co-operation.

[4] Throughout this article the reference is to the Act of 1931.

Section 5 of the Act enables promotors of schemes to provide for the assistance of agricultural co-operation, but does not compel them to do so. Unless the necessary steps are taken to secure powers when schemes are drafted the Boards in control cannot use funds arising from their operations to promote or assist co-operation.[5] Without specific provisions in the schemes themselves any such assistance is beyond the financial powers of the Boards. It therefore behoves all persons interested in agricultural co-operation to review carefully any scheme submitted for their consideration, and to see that substantial provision is made for the co-operative movement which has been, is, and will be, a powerful influence in progressive agriculture.

The application of the Marketing Act will, in all probability, be limited to certain products, but through the passing of the Import Duties Act 1932 there is the possibility of a new progressive era in the development of the marketing of agricultural products. The merits and demerits of tariffs and their possible contribution to the solution of agricultural problems may be discussed, but persons interested in marketing for the time being must accept tariffs as an accomplished fact as part of the law of the land.

Under this Act an Imports Duties Advisory Committee has been set up with unique powers of increasing, decreasing, or removing tariffs by recommendations. Their duty is to consider the adequacy or inadequacy of present import duties and recommend alterations. And it is of interest to note that Orders made by the Treasury on their recommendations are as effective as any statute passed by Parliament. Statements of opinion made by the Committee are therefore of interest as being indicative of the trend of development and the policy they intend to pursue. Emphasis should therefore be placed upon some observations made in recommending an increase upon certain imported horticultural products. Whilst stating the necessity for increased production, the Committee attaches great importance to "improvements in marketing methods, including the organised assembly, grading and packing of the products. The progress made in this direction will be kept under observation in connection with any review of the duties." It is stated definitely that they will not hesitate to recommend the removal of any duties should it appear that, owing to lack of effective organisation, or otherwise, the

[5] The Agricultural Marketing Bill, 1933, includes an amendment to this Section of the Act which will give Boards in control power to *promote or conduct* agricultural co-operation.

prospect of any particular commodity subject to duty being produced in this country of the right quality in substantial quantities, and at a reasonable price, falls short of what may be properly expected.

This statement is a grave warning to all agriculturists and their duty, if they wish to retain the protective tariffs offered, is obvious. Farmers must show a desire to organise for the more effective and economical distribution of their produce. It is immaterial to the Imports Duties Advisory Committee who does the organisation work provided it is done, but it is of material importance to the farmer. Could an " outsider " enter the the marketing system and organise or re-organise it for his own profit this would appear to be sufficient for the Imports Duties Advisory Committee though it would be of little benefit to the farmer. In order to gain what there is to be gained by the imposition of tariffs farmers will be obliged to organise co-operatively or under schemes operated by virtue of the powers of the Marketing Act. Many schemes, it is probable, will be left, for reasons stated above, to voluntary co-operation, and it is clear that advocates of the movement are being offered certain protective measures " to put their house in order." Failure to achieve this will mean either leaving it to private enterprise and allowing the profits earned to be drained from the industry or to the removal of the protective measures which have been made.

In the general policy of the Ministry of Agriculture there has been a marked consistency in supporting co-operation in agricultural marketing. Further, it is of interest to note the statement of policy made by the Development Commissioners in the first report on their proceedings during the period from the 12th May, 1910, (the date of their appointment), to the 31st March, 1911. They directed their agricultural policy into three lines of action; firstly, to increase the amount and quality of the product of agriculture; secondly, to increase the variety of the production, and thirdly, they proposed to encourage agricultural co-operation, " a subject which is expressly named in the Act " as a solution of the commercial problems of agriculture. In their second report the Commissioners outlined the arrangements made for assisting agricultural co-operation in Great Britain, the principle adopted being the utilisation of existing voluntary organisations which had done the work in the past. This policy has been followed closely since the principles were laid down. Considerable help has been provided in the nature of grants and loans to co-operative marketing ventures. In April, 1924, provision was made by

Parliament for loans to co-operative enterprises engaged or proposing to engage in the preparation and marketing of agricultural products. A revised scheme relating to these loans was published in May, 1930. These schemes were administered by an Advisory Committee on Co-operation and Credit which was set up by the Ministry of Agriculture in 1924. For reasons well known to all, such schemes are now in abeyance, but the possibility of their being re-introduced is dependent upon the demand from agricultural co-operators and the progress of the movement. It can be said that the withdrawal of these schemes was not due to any deliberate change in policy of the Ministry to agricultural co-operation, but to a general change which affected all similar schemes in much the same way.

It now seems that, in view of recent developments, the time is ripe for further consideration of the general relations between the Consumers and the Agricultural Co-operative Movement. For nearly thirty years this question has been raised periodically, at times by the Consumers' Movement and at other times by the Agricultural Movement. In spite of prolonged discussions and reviews of the possibilities little appears to have been achieved. It is not proposed to give any of the many reasons offered for this failure to apply the principles to which both movements profess to adhere. The one general criticism, cynical though it may be, is obvious. The present position appears to be one of more or less complete independence, although some very successful and valuable contacts have been established and maintained for many years. The Consumers' Movement offers a very wide market for the home produced agricultural commodities marketed co-operatively and the failure of the farmers' co-operative societies to make and retain contacts with this market is one of the severest indictments against them. The possibilities of mutual gain to both branches are obvious, but they appear to have failed to devise a satisfactory basis of contact. The time is now ripe for a serious attempt to place upon a practical basis the many pious resolutions which have been passed during the last thirty years.

The future of agricultural co-operation depends, to a large extent, upon how the movement meets the general problems outlined above. Greater contact with the Consumers' Movement would stimulate the co-operative marketing of agricultural products. In any case, a development of co-operative marketing would justify the retention of the protective tariffs now offered the industry and would tend to influence the Ministry of Agriculture to re-establish its schemes of financial assistance as soon as general circumstances permit. But it is essential that the possible future

spheres of general activity should be reviewed so that co-operators should have some idea as to the commodity organisations and their forms to which their activities should now be applied.

Established co-operative organisations will have to consider seriously each marketing scheme proposed under the Agricultural Marketing Act, 1931. Provision is made in the Act for a period to be allowed for consideration of all schemes outlined, but the period is limited and it is, therefore, essential that no time should be lost in reviewing and, if necessary, making any recommendations for amendment. All such recommendations will receive consideration before the scheme or schemes are permitted to go forward. But under the Act there is nothing to prevent any co-operative organisation suggesting a scheme for the marketing of any particular product. In fact this possibility forms an important branch of the future work of co-operators. Although it is a most difficult task to outline a satisfactory scheme, there is no doubt that the past experience and failures of co-operative marketing organisations would be a valuable basis upon which to build up a successful marketing scheme. This has already been accomplished in Scotland, where a milk marketing scheme has been built upon the experiences of the Scottish Milk Pool.

Once schemes are in full operation co-operators must consider seriously the possibility of service to their members by " fitting " their co-operative activities within any scheme. It is in this direction that present co-operative organisation can make effective recommendations for the amendment of schemes. In an area where small farmers predominate, organisation is essential to place the smaller farmer on an equal status with the larger farmers predominating in other parts of the country. Where a scheme covers the whole of Britain or even England and Wales, the possibility exists that it will apply more effectively to the larger farmers and the interests of smaller farmers can only be safeguarded by co-operative organisations within the scheme.

Whilst it may be that undue emphasis is being placed upon the application of the Act to agricultural marketing of the future and that there is no reason to anticipate that the present plethora of schemes will continue, care must be taken at the present time as any scheme will have considerable influence upon the future. And the future of independent and true co-operation for the marketing of farm products will always be dominated by the possibility of organisation under the Act. In fact, before any future line of action is determined such a possibility must be borne in mind. It may be of interest to note that the majority of present schemes are of the nature of " horizontal combination " and little

or no work has been done on the possibilities of "vertical combination." Much has been said in the past on the advantage of organisation in bringing the farmer into more direct touch with the ultimate consumer in order to avoid duplication of expenses so frequent in the present unorganised marketing systems. This field offers considerable scope for co-operative organisation of agricultural producers and gives a basis upon which producers' organisations and the consumer organisations could meet for mutual trading and inevitably mutual benefit. But it has been suggested above that future developments in this direction will be dominated by any of the present schemes which come into operation, particularly where these schemes are tending to perpetuate the present system of distribution.

It is also of interest to note that only national schemes are now receiving consideration, though there is nothing in the Act preventing the consideration of purely local schemes. For the present it appears that local organisation for the marketing of products of purely local importance is not likely to receive much consideration from the enthusiasts for large collective schemes. It is therefore mainly in this direction that the future activities of co-operators lie. Particularly will this be important where there is a relatively rapid development of agricultural production in new directions. But even where there is little or no change in the type of products produced the more exacting demands of the consumers and the retail trade will necessitate some considerable development of collection and joint processing to supply the changing market. The marked change in the organisation of the wholesale market, particularly the development of standardised packing and grading, has made the retail trade a comparatively simple business. To enter effectively into this business producers of agricultural produce must arrange for the grading and packing of their produce in the forms required and co-operation offers a very effective method of achieving this at a minimum of cost to the farmer.

A COMPARISON OF THE NITROGEN AND MINERAL CONTENT OF THE PASTURE, HAY AND AFTERMATH OF FOUR SPECIES OF GRASSES GROWN IN A MIXTURE, PURE PLOTS AND PURE DRILLS.

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The object of the investigation outlined in this paper was to ascertain whether the produce of grasses in the form of pasture, hay and aftermath differed in chemical composition when the seeds were sown in mixture, in pure plots or in pure drills.

The land on which the investigation was conducted was under grass plots up to 1928. In the autumn of that year these were ploughed up and lime applied at the rate of two tons per acre. Subsequent to this the land remained fallow until June, 1929, when a catch crop of crimson clover and mustard was taken from it. In February, 1930, the land was again ploughed for a spring fallow, and the present plots were sown on the 12th of May, 1930.

For the purpose of the investigation pedigree indigenous seeds were used, and the station number of these, together with the seeding per acre, is set out below.

Species.	*Station number.*	*Pounds per acre.*	
		In mixture.	*In pure plots.*
Cocksfoot ...	1,163	8	25
Timothy ...	352	8	15
Meadow foxtail ...	284	10	25
Fine-leaved red fescue ...	728	8	20

The plots were four square yards in area, and each drill six feet long. In the latter each species was sown at the rate of six viable seeds per linear inch. The plots and drills were replicated twenty-six times, twenty of these replications being used for the monthly pasture cuts and six for hay and aftermath. A path two feet wide was sown with timothy between the traverses of the plots and around the experimental block. Apart from a dressing of lime in the autumn of 1928, the land had

received no manure, nor was any applied to the plots in the present investigation. In July, 1930, the plots and drills were cut and the produce removed. This was repeated on the 15th of October, 1930.

The first pasture cut was taken on the 5th of May, 1931, and represented the growth from the 15th of October, 1930. The dates at which the different pasture cuts were taken were as follows :—May 5, 1931 ; June 4, 1931 ; July 5, 1931 ; and September 28, 1931.

The hay and aftermath cuts were taken on June 19 and August 27, 1931, respectively.

Method of Sampling.

For each pasture cut a mesh having an inside measurement of one square foot was used. This was thrown at randon four times on each of the small plots and the produce inside the mesh cut with a shears. The herbage thus obtained from four square feet of each plot was mixed with that obtained in a similar manner from the remaining nineteen replications of the same species, and from this pooled herbage a representative sample was taken for chemical analysis. The same procedure was adopted in sampling the aftermath, but in the case of hay, the whole plot was cut with a scythe and a representative sample for analysis taken.

The plots and drills were kept as free as possible from weeds and any that made their appearance in the produce when cut were removed prior to chemical analysis.

The first pasture cut taken on May 5 represented the growth made between October 15 and this date. At this time all the plots looked well, and those in which the four grasses had been sown together—the mixture plots—were even in character and the four species were well represented. In the series of plots and drills the herbage was some four inches in height and of a very leafy character. At the second cutting on June 4 good growth had been made though the herbage, as would be expected at this period of the season, showed more stem in proportion to leaf than at the first cutting. The leaf, however, of all the grasses was quite free from any burn.

The whole area at the third cutting, with the exception of the timothy plots, showed a short grassy growth. Timothy at this date was stemmy with the inflorescence fully emerged. It was observed that the grasses grown in drills were in all cases more stemmy in character than those grown in plots.

Although the grasses had not been cut for two months the bulk at the fourth cutting was small and all showed varying amounts of burn with the exception of fine-leaved fescue.

In Table I the average ratio of stem to leaf in the four pasture cuts is given, and where these averages tend to mask certain characteristics of growth at certain periods of the season attention is drawn to this in the discussion of the results given in this table.

TABLE I.

Average ratio of stem to leaf in the four pasture cuts of the four grasses grown in a mixture, in pure plots and in pure drills.

Species.	*Mixture.*	*Pure plots.*	*Pure drills.*
Cocksfoot ...	1 : 5.8	1 : 6.8	1 : 3.2
Timothy ...	1 : 3.5	1 : 3.7	1 : 2.3
Meadow foxtail ...	1 : 10.8	1 : 11.1	1 : 4.7
Fine-leaved red fescue ...	1 : 12.3	1 : 8.8	1 : 5.0

The high proportion of leaf to stem in fine leaved fescue in the mixture plot is characteristic of the grass when grown with other species, for under such conditions, if well represented, it provides a great part of the bottom growth in the form of leafy herbage. This high proportion of leaf to stem was very marked in the third and fourth cuts when fine-leaved fescue was grown in a mixture, and in these cuts the ratio of stem to leaf was 1 : 16 in the third and 1 : 25 in the fourth cuts respectively. Again meadow foxtail in the first, second and last cuts was exceedingly leafy, especially in the mixture and pure plots. Thus in the third cut the proportion of stem to leaf in the mixture was 1 : 16 and in the pure plots 1 : 18. It will be seen from Table I that the ratio of stem to leaf was consistently higher in all four grasses when grown in drills, the difference between meadow foxtail and fine-leaved fescue grown in drills compared with the same grasses grown in mixture and in plots being very pronounced.

Of the four grasses under investigation, timothy under the three conditions of sowing had the highest proportion of stem to leaf in all cuts but the second. In this cut the proportion of stem to leaf was higher in fine-leaved fescue owing to the earlier maturity of this grass.

The average percentage composition of the four grasses grown under different conditions is given in Table II, and where the average figures tend to mask differences in individual cuts attention is drawn to this in the discussion of the results.

On examining Table II, the slight differences in the average percentage composition of each of the four grasses sown under the varying conditions of the investigation is very striking. Of the constituents determined, the nitrogen and potash are seen to

TABLE II.

The average percentage composition of the dry matter of four pasture cuts of cocksfoot, timothy, meadow foxtail, and fine-leaved fescue grown in a mixture, pure plots and pure drills.

Species.	*Grown in*	*Nitrogen.* N.	*Phosphoric Acid.* P_2O_5	*Potash.* K_2O	*Lime.* CaO	*Chlorine.* Cl.
Cocksfoot ...	Mixture	1.89	0.88	3.95	1.10	0.99
Cocksfoot ...	Pure plots	1.86	0.87	3.87	0.99	1.05
Cocksfoot ...	Drills	1.91	0.80	4.01	0.78	0.81
Timothy ...	Mixture	1.68	0.66	3.11	0.75	0.74
Timothy ...	Pure plots	1.77	0.71	3.13	0.76	0.89
Timothy ...	Drills	1.86	0.70	3.22	0.70	0.82
Meadow foxtail ...	Mixture	2.03	0.91	3.40	0.89	0.83
Meadow foxtail ...	Pure plots	1.95	0.82	3.51	0.82	0.79
Meadow foxtail ...	Drills	2.06	0.75	3.56	0.78	0.75
Fine-leaved fescue ...	Mixture	1.63	0.69	3.09	0.72	0.62
Fine-leaved fescue ...	Pure plots	1.48	0.74	3.04	0.77	0.58
Fine-leaved fescue ...	Drills	1.76	0.72	3.52	0.70	0.74

be consistently higher, and the lime lower, in the grass when grown in drills compared with the same grass grown in a mixture or in pure plots. Although these consistent differences are to be found when the average composition of the four pastures are considered, this was not always the case with the individual cuts.

For example, the second cut taken on June 4 contained a higher proportion of stem to leaf in all the grasses except timothy. In timothy, as already intimated, the proportion of

stem to leaf was at its highest in the third cutting taken on July 6. The effect of the attempt which all the grasses made to reproduce themselves in spite of the fact that they were cut at approximately monthly intervals was that at this period they became more stemmy, and this affected their chemical composition. Thus, in the case of cocksfoot, meadow foxtail and fine-

TABLE III.

Average percentage composition of the dry matter of the stem of four pasture cuts of cocksfoot, timothy, meadow foxtail, and fine-leaved fescue grown in a mixture in pure plots and in pure drills.

Species.	*Grown in*	*Nitrogen.* N.	*Phosphoric Acid.* P_2O_5	*Potash.* K_2O	*Lime.* CaO	*Chlorine.* Cl.
Cocksfoot ...	Mixture	1.42	1.06	3.92	0.69	1.29
Cocksfoot ...	Pure plots	1.41	0.94	3.95	0.67	1.24
Cocksfoot ...	Pure drills	1.71	0.95	4.23	0.51	1.29
Timothy ...	Mixture	1.37	0.69	3.43	0.42	0.76
Timothy ...	Pure plots	1.56	0.91	3.23	0.45	0.76
Timothy ...	Pure drills	1.62	0.73	3.71	0.42	0.81
Meadow foxtail ...	Mixture	1.54	0.84	3.80	0.52	0.80
Meadow foxtail ...	Pure plots	1.46	0.82	3.94	0.45	0.85
Meadow foxtail ...	Pure drills	1.56	0.79	3.99	0.38	0.73
Fine-leaved fescue ...	Mixture	1.21	0.68	2.95	0.38	0.50
Fine-leaved fescue ...	Pure plots	1.30	0.71	3.13	0.42	0.55
Fine-leaved fescue ...	Pure drills	1.64	0.90	3.57	0.40	0.76

leaved fescue, the percentage of each constituent determined was lower in the cut taken on June 4 than in that of May 5 or July 6, whereas in the case of timothy it was in the July cut as compared with June and September that this fall was most obvious. Thus, in spite of the fact that the period of the season

at which this attempt of the grasses to reproduce themselves varied, its effect on their composition holds true under all three conditions of growth. On comparing the average composition of the pasture cuts of the individual grasses, cocksfoot and meadow foxtail, irrespective of the manner in which they were grown, are seen to be richer in nitrogen, phosphoric acid, lime and potash than timothy or fine leaved fescue. Cocksfoot and meadow foxtail have also a high chlorine content, though timothy closely approximates them in this constituent.

A portion of each of the four samples of pasture cuts was separated into stem and leaf and both of these were subjected to chemical examination. The result of the chemical examination of the stem is shown in Table III.

Of the constituents determined, it will be noted that the nitrogen and potash are higher in the grasses grown in drills, and in this respect the stem resembles the whole plant. The stems of cocksfoot and meadow foxtail still further resemble the whole plant in that their lime content is at its lowest when grown in drills. Apart from this, the stems show no consistent differences in composition that might be attributed to the particular manner in which they were grown..

When the composition of the different stems are compared, the nitrogen content of cocksfoot, timothy and meadow foxtail are generally higher than that of fine-leaved fescue, and the stem of cocksfoot is richer in phosphoric acid, potash, lime and chlorine than is the stem of the other grasses.

Further discussion of the results shown in Table III and their effect on the composition of the whole pasture plant will be facilitated on reference to Table IV, in which the average composition of the leaf of the four pasture cuts is given.

All the characteristic differences in composition between the leaf and stem, to which attention has been drawn in previous publications (1), are to be seen on comparing Tables III and IV. Thus the Nitrogen and Lime content of the leaf is higher than that of the stem, while the phosphoric acid, potash and chlorine content of the stem is generally higher than the leaf.

Taking the grasses in order, it is seen that the average nitrogen and potash content of the leaf, as in the stem, is consistently higher in the grasses grown in drills. When the individual pasture cuts, however, are taken into consideration this is true only for meadow foxtail, for in the last cut of cocksfoot, timothy and fine-leaved fescue grown in drills, the percentage of nitrogen is lower than when these grasses are grown in mixture or in pure plots.

When the average percentage composition of the produce of the pasture cuts of the grasses grown under the conditions of the investigation are compared, the manner in which they were grown does not appear to have any very appreciable effect upon

TABLE IV.

The average percentage composition of the dry matter of the leaf of four pasture cuts of cocksfoot, timothy, meadow foxtail and fine-leaved fescue grown in a mixture, in pure plots and in pure drills.

Species.	*Grown in*	*Nitrogen. N.*	*Phosphoric Acid. P_2O_5*	*Potash. K_2O*	*Lime. CaO*	*Chlorine. Cl.*
Cocksfoot ...	Mixture	1.93	0.87	3.89	1.18	0.80
Cocksfoot ...	Pure plots	2.01	0.79	3.93	1.20	1.15
Cocksfoot ...	Pure drills	2.16	0.70	4.40	0.96	0.87
Timothy ...	Mixture	1.82	0.63	3.16	0.91	0.65
Timothy ...	Pure plots	1.75	0.61	3.05	0.92	0.64
Timothy ...	Pure drills	2.14	0.66	3.40	0.95	0.63
Meadow foxtail ...	Mixture	1.94	0.74	3.03	0.89	0.84
Meadow foxtail ...	Pure plots	2.13	0.67	3.35	0.87	0.71
Meadow foxtail ...	Pure drills	2.34	0.69	3.53	0.79	0.73
Fine-leaved fescue ...	Mixture	1.73	0.72	3.20	0.76	0.62
Fine-leaved fescue ...	Pure plots	1.65	0.67	2.97	0.81	0.43
Fine-leaved fescue ...	Pure drills	1.82	0.65	3.43	0.82	0.69

their composition. There are, however, certain small consistent differences in chemical composition between them. Thus the grasses grown in drills have a higher percentage of nitrogen and potash and a lower percentage of lime than the same grasses grown in a mixture or in pure plots. This difference in favour of the grasses grown in drills is of the type generally found when

the composition of the produce of the border rows of experimental plots is compared with that of the remainder, and doubtless the reason for this is one and the same in both cases.

Though the difference in chemical composition between the pasture cuts grown under these different methods is small, the type of growth made by the grasses is considerably affected. Thus the grasses grown in drills, as would be expected, made a more vigorous growth, with the result that the ratio of stem to leaf in these grasses was higher. The composition of the stem of the grasses grown in drills, however, was superior to that of the stem of the same grass grown in mixture and in pure plots, with the result that the effect of the high ratio of stem to leaf on the chemical composition of the produce is not so great as that usually associated with such a ratio (2).

Hay.

The mixture plots at hay cutting time, June 19th, 1931, showed a good blend of all four grasses, fine-leaved fescue being the most advanced in growth, the remainder of the grasses having few inflorescences.

In the pure plots cocksfoot was a dense leafy growth with relatively few flowering stems, while the timothy plots which were the latest in maturing looked well with their stems elongated for flowering. Meadow foxtail, although an early grass to flower, had very few inflorescences, and its herbage in these plots was extremely leafy for a hay growth.

The grasses grown in drills had in every case produced more stem than when grown in either a mixture or in pure plots. An indication of the type of growth made by each grass at the time of cutting for hay is given in the following Table, where the ratio of stem to leaf of each of the grasses grown in mixture, pure plots and drills is given.

TABLE V.

Species.	*Mixture.*	*Pure plots.*	*Pure drills.*
Cocksfoot ...	1 : 1.5	1 : 1.8	1 : 0.5
Timothy ...	1 : 1.2	1 : 1.0	1 : 1.0
Meadow foxtail ...	1 : 3.7	1 : 3.0	1 : 1.0
Fine-leaved red fescue ...	1 : 1.0	1 : 0.5	1 : 0.3

The above Table confirms to a large extent the observations made on the appearance of the plots at the time of cutting. All

the grasses show a higher proportion of stem to leaf when grown in drills. Fine-leaved fescue was the most mature and meadow foxtail, both in the mixture and in pure plots, was more leafy than any of the other grasses. Further, it may be said that on the whole the ratio of stem to leaf is lower when the grasses are grown in mixture than in pure plots.

The following Table gives the result of the chemical examination of the hays harvested from each grass grown under the different conditions of the investigation.

TABLE VI.

The percentage composition of the dry matter of the hay cuts of cocksfoot, timothy, meadow foxtail and fine-leaved fescue grown in a mixture, pure plots, and in pure drills.

Species.	*Grown in*	*Nitrogen.* N.	*Phosphoric Acid.* P_2O_5	*Potash.* K_2O	*Lime.* CaO	*Chlorine.* Cl.
Cocksfoot ...	Mixture	1.30	0.73	3.80	0.88	0.99
Cocksfoot ...	Pure plots	1.29	0.52	3.80	0.91	0.83
Cocksfoot ...	Drills	1.46	0.61	3.00	0.77	0.70
Timothy ...	Mixture	1.17	0.49	3.43	0.61	0.76
Timothy ...	Pure plots	1.10	0.59	3.22	0.59	0.85
Timothy ...	Drills	1.31	0.59	2.91	0.62	0.83
Meadow foxtail ...	Mixture	1.57	0.56	3.36	0.68	0.84
Meadow foxtail ...	Pure plots	1.89	0.55	3.14	0.53	0.88
Meadow foxtail ...	Drills	1.84	0.54	3.12	0.48	0.83
Fine-leaved fescue ...	Mixture	1.01	0.47	2.76	0.50	0.52
Fine-leaved fescue ...	Pure plots	0.84	0.49	2.28	0.40	0.50
Fine-leaved fescue ...	Drills	1.06	0.45	2.83	0.46	0.56

The only consistent difference in the composition of the grasses as hay is in their nitrogen content, which is at its highest

and lowest when grown in drills and pure plots respectively. In this the hay agrees with the majority of the grasses cut as pasture (See Table II). The hay and pasture cuts of meadow foxtail are outstanding in their nitrogen content, and this is more particularly the case when the grass is grown in drills. This

TABLE VII.

Percentage composition of the dry matter of the stem of the hay cuts of cocksfoot, timothy, meadow foxtail and fine-leaved fescue grown in a mixture, pure plots and pure drills.

Species.	*Grown in*	*Nitrogen.* N.	*Phosphoric Acid.* P_2O_5	*Potash.* K_2O	*Lime.* CaO	*Chlorine.* Cl.
Cocksfoot ...	Mixture	1.00	0.76	4.30	0.52	1.24
Cocksfoot ...	Pure plots	1.15	0.86	4.20	0.53	0.92
Cocksfoot ...	Drills	0.98	0.60	2.85	0.36	0.78
Timothy ...	Mixture	0.82	0.57	3.29	0.31	1.03
Timothy ...	Pure plots	0.88	0.70	3.50	0.32	1.06
Timothy ...	Drills	1.13	0.65	3.70	0.37	1.17
Meadow foxtail ...	Mixture	1.12	0.52	3.63	0.33	1.06
Meadow foxtail ...	Pure plots	1.08	0.67	3.53	0.36	1.06
Meadow foxtail ...	Drills	1.33	0.51	4.02	0.28	0.96
Fine-leaved fescue ...	Mixture	0.84	0.45	2.13	0.37	0.56
Fine-leaved fescue ...	Pure plots	0.72	0.48	2.31	0.28	0.56
Fine-leaved fescue ...	Drills	0.97	0.48	2.42	0.31	0.64

latter result in the hay is at first sight contrary to what would be expected, seeing that when grown in drills the proportion of stem to leaf is at its highest. Reference, however, to Table VII shows the nitrogen content of the stem of meadow foxtail to be higher than the stem of the remaining grasses and to compare very favourably with the nitrogen content of the leaf of some grasses

grown in mixture and pure plots. Cocksfoot comes next to meadow foxtail in its nitrogen content, but in phosphoric acid and lime is the richest of the four grasses. A comparison of timothy with fine-leaved fescue is of interest in that fine-leaved fescue is the earliest and timothy the latest to come to maturity. Table VI shows that, irrespecive of the manner in which the grasses were grown, fine-leaved fescue, as would be expected (8) is poorer in all the constituents determined.

A portion of the hay sample of each grass was separated into stem and leaf and both were subjected to chemical examination. The result of the examination of the stem is given in Table VII.

With the exception of cocksfoot, the stem of the remaining grasses when grown in drills is higher in nitrogen and potash than is the stem of the same grass grown in mixture or in pure plots. The phosphoric acid content, on the other hand, is in the majority of cases higher in the same grass when grown in pure plots.

From what has already been said when discussing the composition of the hays, the composition of the stem of fine-leaved fescue compared with that of the remainder of the grasses is seen to give all the indications of having reached a more advanced stage of maturity (4), being poorer in nitrogen, phosphoric acid, potash, lime and chlorine.

The leaves of the hay show similar differences to those indicated in the stems, and the results of their chemical examinations is given in Table VIII.

The nitrogen in the leaf of the grasses, as in the stem, is higher when grown in drills, though the potash, lime and chlorine content of the grasses are on the whole lower when grown in this manner. A comparison of the leaves of the different grasses shows those of meadow foxtail, followed by cocksfoot, to be the richest in nitrogen, timothy and fine-leaved fescue being very similar in this constituent. The leaf of the hays compared with the stem—Tables VII and VIII—shows similar differences to those already indicated between the leaf and stem of the pasture cuts, that is, the leaf is superior to the stem in nitrogen and lime, but the phosphoric acid content of the stem is on the whole higher than the leaf.

In the hay, as in the pasture, the nitrogen content of all the grasses is higher when grown in drills. Further, the stem of most of the grasses grown in drills is higher in nitrogen than that generally found in the same grass under ordinary conditions of growth. Indeed the nitrogen content of the stem of meadow foxtail when thus grown compares favourably with the leaf of some grasses grown in mixture and in pure plots. The reason

for this superiority in composition of the hay of the grasses grown in drills is doubtless accounted for in a similar manner to that advanced for the superiority of the pasture of the grasses grown in drills.

TABLE VIII.

Percentage composition of the dry matter of the leaf of the hay of cocksfoot, timothy, meadow foxtail and fine-leaved fescue grown in a mixture, pure plots and in pure drills.

Species.	*Grown in*	*Nitrogen.* *N.*	*Phosphoric Acid.* P_2O_5	*Potash.* K_2O	*Lime.* *CaO*	*Chlorine.* *Cl.*
Cocksfoot ...	Mixture	1.43	0.62	3.32	1.13	0.88
Cocksfoot ...	Pure plots	1.42	0.73	4.28	1.15	0.81
Cocksfoot ...	Drills	1.78	0.63	3.11	0.80	0.64
Timothy ...	Mixture	1.39	0.67	3.00	0.88	0.67
Timothy ...	Pure plots	1.27	0.54	3.00	0.87	0.64
Timothy ...	Drills	1.63	0.47	2.61	0.84	0.35
Meadow foxtail ...	Mixture	1.63	0.50	2.74	0.78	0.71
Meadow foxtail ...	Pure plots	1.77	0.60	2.98	0.70	0.92
Meadow foxtail ...	Drills	2.21	0.58	2.88	0.59	0.64
Fine-leaved fescue ...	Mixture	1.44	0.56	3.61	0.72	0.78
Fine-leaved fescue ...	Pure plots	1.09	0.58	3.63	0.85	0.67
Fine-leaved fescue ...	Drills	1.65	0.59	3.08	0.91	0.78

Aftermath.

All the plots looked extremely well when the aftermath was cut on August 27, fine-leaved fescue being particularly leafy. The grasses grown in drills were again characterised by their high proportion of stem to leaf.

The Table below, where the ratio of stem to leaf in the aftermath of each grass grown under the different conditions of the

experiment is shown, will give an indication as to the appearance of the plots at the time of cutting.

TABLE IX.

Species.	*Mixture.*	*Pure plots.*	*Pure drills.*
Cocksfoot ...	1 : 4.1	1 : 4.9	1 : 8.2
Timothy ...	1 : 3.0	1 : 3.8	1 : 1.0
Meadow foxtail ...	1 : 7.4	1 : 7.2	1 : 5.5
Fine-leaved red fescue ...	1 : 12.8	1 : 12.4	1 : 9.4

Table IX illustrates the leafiness of the aftermath of fine-leaved fescue whether grown in mixture, pure plots or drills. Further, the high proportion of stem to leaf in the aftermath of the majority of the grasses grown in drills compared with those grown in mixture or in pure plots is very striking. In Table X the percentage composition of the aftermath of the four grasses grown under the different conditions is shown.

The nitrogen content of the aftermath of the majority of the grasses is higher when these are grown in drills than when grown in mixture or in pure plots. Meadow foxtail, however, is a notable exception, for in this grass the nitrogen is higher in the aftermath when grown in mixture, though as pasture and hay it agrees with the other grasses in that its nitrogen content is higher when grown in drills. The phosphoric acid in the aftermath is consistently higher in the four grasses grown in pure plots, while the lime is at its lowest and the chlorine at its highest when grown in drills.

On comparing the aftermath of the grasses irrespective of the conditions under which they were grown, it may be said that meadow foxtail provides the aftermath richest in nitrogen followed by cocksfoot, fine-leaved fescue and timothy being similar in nitrogen content.

A comparison of the aftermath of each grass with the average composition of the four pasture cuts—Tables II and X—shows that the pasture is generally richer in the constituents determined. The aftermath of meadow foxtail, however, is slightly richer in nitrogen when grown in mixture and in drills than is the pasture of this grass grown under similar conditions. A similar comparison of the aftermath with the hay—Tables VI and X—indicates that the aftermath in the large majority of the constituents determined stands in an intermediate position between the pasture and the hay.

TABLE X.

Percentage composition of the dry matter of the aftermath of cocksfoot, timothy, meadow foxtail and fine-leaved fescue grown in a mixture, pure plots and in pure drills.

Species.	*Grown in*	*Nitrogen.* N.	*Phosphoric Acid.* P_2O_5	*Potash.* K_2O	*Lime.* CaO	*Chlorine.* Cl.
Cocksfoot ...	Mixture	1.35	0.73	3.50	0.98	0.92
Cocksfoot ...	Pure plots	1.37	0.75	3.36	0.92	0.99
Cocksfoot ...	Drills	1.60	0.60	3.34	0.80	0.99
Timothy ...	Mixture	1.28	0.52	2.49	0.85	0.64
Timothy ...	Pure plots	1.41	0.54	1.99	0.73	0.71
Timothy ...	Drills	1.30	0.41	2.20	0.58	0.85
Meadow foxtail ...	Mixture	2.33	0.53	2.89	0.86	0.56
Meadow foxtail ...	Pure plots	1.49	0.58	2.67	0.84	0.71
Meadow foxtail ...	Drills	2.08	0.52	2.96	0.57	0.85
Fine-leaved fescue ...	Mixture	1.39	0.55	3.01	0.74	0.64
Fine-leaved fescue ...	Pure plots	1.24	0.68	3.15	0.85	0.42
Fine-leaved fescue ...	Drills	1.44	0.63	3.03	0.69	0.92

The aftermath was separated into stem and leaf and both were subjected to chemical examination. Table XI gives the chemical composition of the stem of the aftermath of each grass grown under different conditions.

Apart from meadow foxtail, the nitrogen and potash content of the stem of the aftermath, as in the stems of the pasture and hay, are consistently higher in the grasses grown in drills than in the same grasses grown in mixture or pure plots. Of the remaining constituents, the phosphoric acid in the majority of the grasses is higher when grown in pure plots, but the potash, lime and chlorine show no consistent differences in the grasses

as a result of being grown in a particular manner. A comparison of the grasses among themselves shows the stems of meadow foxtail and fine-leaved fescue to be richer in nitrogen than the stem

TABLE XI.

Percentage composition of the dry matter of the stem of the aftermath of cocksfoot, timothy meadow foxtail and fine-leaved fescue grown in mixture, pure plots and in pure drills.

Species.	*Grown in*	*Nitrogen.* N.	*Phosphoric Acid.* P_2O_5	*Potash.* K_2O	*Lime.* CaO	*Chlorine.* Cl.
Cocksfoot ...	Mixture	0.97	0.81	3.82	0.61	1.24
Cocksfoot ...	Pure plots	1.01	0.96	3.87	0.64	1.56
Cocksfoot ...	Drills	1.06	0.64	3.84	0.50	1.49
Timothy ...	Mixture	0.91	0.48	2.50	0.77	0.61
Timothy ...	Pure plots	0.95	0.52	2.30	0.50	0.56
Timothy ...	Drills	0.96	0.51	2.85	0.45	0.64
Meadow foxtail ...	Mixture	1.62	0.49	2.76	0.46	0.77
Meadow foxtail ...	Pure plots	1.11	0.59	2.47	0.47	0.95
Meadow foxtail ...	Drills	1.43	0.57	3.25	0.42	0.85
Fine-leaved fescue ...	Mixture	1.22	0.58	3.10	0.44	0.60
Fine-leaved fescue ...	Pure plots	1.08	0.62	3.02	0.52	0.62
Fine-leaved fescue ...	Drills	1.30	0.66	3.43	0.42	0.64

of cocksfoot and timothy, but apart from this one constituent these two grasses are not outstanding in any other. Thus of the four grasses examined the stem of the aftermath of cocksfoot is the richest in the remaining constituents.

On the whole it may be said that the composition of the stems of the aftermath occupy an intermediate position between those of the stems of pastures and hays.

In Table XII the composition of the leaf of the aftermath is given.

TABLE XII.

Percentage composition of the dry matter of the leaf of the aftermath of cocksfoot, timothy, meadow foxtail and fine-leaved fescue grown in a mixture, pure plots and in pure drills.

Species.	*Grown in*	*Nitrogen.* N.	*Phosphoric Acid.* P_2O_5	*Potash.* K_2O	*Lime.* CaO	*Chlorine.* Cl.
Cocksfoot ...	Mixture	1.43	0.62	3.32	1.13	0.88
Cocksfoot ...	Pure plots	1.52	0.75	3.49	0.97	1.70
Cocksfoot ...	Drills	1.79	0.54	3.02	0.85	0.71
Timothy ...	Mixture	1.40	0.52	2.47	0.98	0.56
Timothy ...	Pure plots	1.51	0.54	2.48	0.91	0.67
Timothy ...	Drills	1.70	0.50	2.77	0.72	0.49
Meadow foxtail ..	Mixture	2.53	0.52	2.77	0.91	0.52
Meadow foxtail ..	Pure plots	1.68	0.57	2.79	0.96	0.64
Meadow foxtail ..	Drills	2.13	0.54	2.80	0.68	0.64
Fine-leaved fescue ...	Mixture	1.43	0.56	3.24	0.74	0.49
Fine-leaved fescue ...	Pure plots	1.35	0.74	3.09	0.89	0.56
Fine-leaved fescue ...	Drills	1.53	0.62	2.99	0.78	0.99

The percentage of nitrogen in the leaf as in the stem of the aftermaths is highest in the grasses grown in drills with the one exception of meadow foxtail, where the nitrogen as in the stem is highest in this grass grown in a mixture. The phosphoric acid content of the leaf resembles the stem, being higher in the grasses grown in pure plots.

A comparison of the leaves of the different grasses shows that those of meadow foxtail are richest in nitrogen, and that the

difference in this constituent is small between the leaves of cocksfoot and timothy.

The general conclusions to be drawn from this investigation are :—

(1) That whether as pasture, hay or aftermath, the nitrogen content of the grasses grown in drills is consistently higher than in the same grass grown in mixture or in pure plots. This is probably due to the factors influencing outer rows, and referred to as border effect, in experimental plots. Further, the effort made to keep the plots free from weeds would have a more disturbing effect on the soil of the grasses grown in drills and would resemble hoeing with its attendant influence on nitrification.

(2) That the grasses grown in drills made a more vigorous growth and the herbage had a higher proportion of stem to leaf. However, the stems of the grasses grown in drills have a higher nitrogen content than the stems of the grasses grown in mixture or in pure plots. The result of these two facts is that the composition of the herbage is higher in nitrogen than that generally associated with a growth of this character.

(3) That the potash content of the same grass as pasture is consistently higher when grown in drills, while the lime of both pasture and aftermath is lower when grown in drills than when grown in mixture or in pure plots.

(4) That the phosphoric acid content of the aftermath of the grasses grown in pure plots is always higher than when the same grass is grown in mixture or in pure drills.

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NOTE ON THE MINERAL CONTENT OF SOME TYPICAL NORTH WALES PASTURES.

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Much of the grazing land in North Wales is situated on poor upland, and it is well known that stock continually grazing on certain pastures eventually show symptoms of a disease, known

locally as "braner", which is apparently the well-known disease "pica". Chemical analyses are not necessary in order to be convinced that the mountain grazings in this area have a low content of minerals, for stock have been grazing these

TABLE I.

Centre.	*Type of Pasture.*	*Soil types.*	*Drainage conditions.*	*Topography.*
Dwyran, Anglesey	Fatting	Reddish-brown medium loam from Carboniferous Limestone.	Free	Gently undulating
Henfaes, C'von.	Fatting	Dark brown medium loam of shale deltaic drift origin.	Satisfactory	Undulating
Lledwigan, Anglesey	Fatting	Reddish-brown light loam, generally deep, from Carboniferous Limestone	Satisfactory	Sloping
Bodffordd, Anglesey	Fatting	Brown light loam. Origin, micaceous schist drift.	Satisfactory	Gently undulating
Aber. T.12, C'von.	Dairy	Greyish-brown medium to heavy loam. Shale drift overlying Keuper Marl.	Satisfactory	Undulating
Croes Yokin, Denbigh	Dairy	Brown sandy loam of Triassic sandy boulder clay origin.	Slightly impeded	Sloping
Bodvel Hall. C'von.	Good store	Brown medium to heavy loam. Ordovician shale boulder clay.	Slightly impeded	Undulating
Efail Newydd, C'von.	Good store	Brown sandy light loam. Ordovician shale sandy boulder clay ...	Satisfactory	Flat
Aber, C'von.	Ffriddoedd	Reddish-brown gritty stony light loam. Eroded profile of Ordovician shale drift.	Free	Steeply sloping
Gorddinan, C'von.	Poor	0-4in. peat below 4in. greyish-brown gritty heavy loam.	Impeded	Steeply sloping
Ffridd. C'von.	Poor	Lacustrine peat overlying greyish-brown clay.	Impeded	Flat
Pwll-y-Garth, C'von.	Poor	Deep black amorphous peat.	Impeded	Flat
Pant Glas, C'von.	Poor grass heath	Gritty loam from grits and felsite.	Free	Steep slope
Pant Glas, C'von.	Heather	Gritty loam from grits and felsite.	Free	Steep slope
Llandegla, Denbigh	Heather	Deep lacustrine peat.	Impeded	Flat

pastures for generations, during which time no artificial treatment has been given to maintain fertility. The work to be described in the present paper was undertaken with a view to ascertaining the extent to which impoverishment has taken place,

and consisted in making comparative analyses of samples taken from various pastures with known grazing reputation.

The pastures from which samples were taken include first-class fatting pastures and dairy pastures, as well as poor upland sheep walks known to be associated with symptoms of mineral deficiency, manifested by abnormal appetites, leading to the eating of bones, clothes, iron, etc.

A description of the centres from which samples were taken is given in Table I.

In Table II are given some analytical data for the soils of these pastures.

Soil.	*Hygroscopic moisture.*	*Loss on ignition.*	*pH*	*Exchangeable CaO*	*Available P_2O_5*
Dwyran ...	3.16	7.90	5.44	0.270	0.014
Henfaes ...	2.36	8.88	5.20	0.203	0.025
Lledwigan ...	3.40	10.98	6.24	0.394	0.012
Bodffordd ...	4.22	11.70	4.96	0.115	0.021
Aber T.12 ...	3.02	8.96	5.08	0.176	0.020
Croes Yokin ...	3.80	9.76	5.92	0.459	0.016
Bodvel Hall ...	—	—	5.76	—	—
Efail Newydd ...	—	—	5.40	—	—
Aber ...	6.22	18.72	4.32	0.041	0.017
Gorddinan ...	4.96	18.36	4.68	0.034	0.011
Ffridd ...	14.20	74.32	4.40	0.130	0.009
Pwll-y-Garth ...	12.56	69.42	4.38	0.293	—
Pant Glas, poor grass heath ...	9.74	49.04	3.58	0.098	0.014
Pant Glas, heather ...	10.72	44.86	4.04	0.092	0.017
Llandegla ...	13.92	55.82	4.64	0.604	0.010

In order that the analyses should be strictly comparable, all the samples were taken about the same time—in the Autumn of 1929. Seasonal variation was thus ruled out as far as possible.

The methods used for the pasture analyses are those employed by Fagan (1); the soils were analysed by the usual methods.

The composition of the pasture samples is shown in Table III.

TABLE III.

Centre.	*Type of Pasture.*	*Nitrogen.*	*Crude fibre.*	*Ash.*	*Si-free ash.*	*CaO*	P_2O_5	*Ratio* CaO/P_2O_5
Dwyran ...	Fatting	3.657	18.4	8.934	5.660	0.632	1.014	0.61
Henfaes ...	Fatting	3.831	17.9	8.786	5.986	0.767	0.884	0.87
Liedwigan ...	Fatting	3.615	20.0	9.085	6.317	0.875	0.881	1.1
Bodffordd ...	Fatting	3.105	17.5	8.166	3.975	0.807	0.752	1.1
Aber, T.12 ...	Dairy	4.091	17.1	8.996	[illegible].649	0.931	1.029	0.90
Croes Yokin ...	Dairy	4.149	19.2	11.110	[illegible].847	0.775	1.035	0.75
Bodvel Hall ...	Good store	4.099	17.1	8.857	6.029	0.917	0.893	1.0
Efail Newydd ...	Good store	2.967	21.0	8.525	4.402	0.866	0.737	1.2
Aber ...	Ffriddoedd	3.235	21.9	8.235	5.859	0.616	0.809	0.76
Gorddinan ...	Poor	2.220	26.4	5.461	3.027	0.450	0.329	1.1
Ffridd ...	Poor	1.748	28.1	3.989	1.998	0.502	0.320	1.6
Pwll-y-Garth ...	Poor	2.707	25.9	—	—	0.518	0.314	1.7
Pant Glas ...	Poor grass heath	2.211	26.3	5.711	1.901	0.161	0.329	0.49
Pant Glas ...	Heather	2.830	24.4	6.[illegible]89	3.154	0.205	0.099	2.1
Llandegla ...	Heather	1.788	27.2	3.628	2.203	0.548	0.210	2.6
Llandegla ...	Heather tips	1.367	23.0	2.514	2.168	0.738	0.239	3.1

Discussion of the analytical figures.

The figures for phosphate show marked contrasts. The average figure for forty-eight samples of good cultivated pastures in Great Britain given by Orr (2) is 0.765 per cent. P_2O_5. With the exception of two cases, the cultivated pastures analysed in this work give a higher figure than this. It must be remembered, however, that only cultivated pastures of outstanding merit were chosen for the present work. The poor pastures show great impoverishment of phosphate, the percentages being of the same order as those of the pastures in the Island of Lewis.

Orr gives 1.104 as the percentage CaO in good cultivated pasture herbage. This is a considerably higher figure than was obtained for the North Wales pastures. The differences in the figures for calcium are less marked than are those for phosphate. The large amount of calcium in the Llandegla herbage may be attributed to the fact that the area sampled was a lacustrine deposit which receives the drainage from the surrounding slopes. The same remark applies to the Pwll-y-Garth peat. The Pant Glas herbage is very deficient in calcium; even more so than that of the Island of Lewis.

In the Llandegla district it is well known that Scotch Blackface sheep do very much better than Welsh sheep. The Blackface sheep select the heather tips, whilst the Welsh breed feeds almost exclusively on the grass herbage. It is significant, therefore, that the phosphate and calcium content of the heather tips is higher than that of the grass herbage.

With the exception of the poor grass heath sample, the ratio CaO/P_2O_5 is greater in the poor than in the good pastures.

Compared with the figures given by Orr, in every case the nitrogen figures are higher in the good North Welsh pastures, whilst the crude fibre figures are considerably lower. With one exception the silica-free ash is lower in the Welsh pastures

Comparison of the figures for the composition of the herbage with soil data does not reveal any marked correlation either between herbage CaO and exchangeable CaO, or between herbage P_2O_5 and available P_2O_5. The large proportion of organic matter in the poorer types doubtless affects the availability of the calcium and the phosphate. In order to ascertain if this could be allowed for, the herbage CaO and P_2O_5 were compared with exchangeable CaO / (loss on ignition) and available P_2O_5 / (loss on ignition) respectively. The figures are set out in Table IV.

Whilst the correlation in the case of the lime figure is still doubtful, in the case of the P_2O_5 figures there does appear to be a correlation between the herbage P_2O_5 and available P_2O_5/

(loss on ignition). The correlation is not markedly significant, but it will be observed that the lowest herbage P_2O_5 figures correspond with the lowest available P_2O_5 / (ignition loss)

TABLE IV.

Centre.	Type of Pasture.	$\frac{\text{Available } P_2O_5}{\text{Ignition loss}} \times 100.$	Herbage P_2O_5	$\frac{\text{Exchangeable } CaO}{\text{Ignition loss}} \times 10.$	Herbage CaO
Dwyran	Fatting	0.177	1.044	0.342	0.632
Henfaes	Fatting	0.282	0.884	0.229	0.767
Lledwigan	Fatting	0.109	0.881	0.359	0.875
Bodffordd	Fatting	0.180	0.752	0.098	0.807
Aber. T.12	Dairy	0.223	1.029	0.196	0.931
Croes Yokin	Dairy	0.164	1.035	0.470	0.775
Aber	Ffriddoedd	0.091	0.809	0.022	0.616
Gorddinan	Poor	0.060	0.329	0.019	0.450
Ffridd	Poor	0.012	0.320	0.018	0.502
Pant Glas	Poor grass heath	0.030	0.329	0.021	0.161
Pant Glas	Heather	0.036	0.099	0.021	0.205
Llandegla	Heather	0.018	0.210	0.108	0.548
Llandegla	Heather tips	0.018	0.239	0.108	0.738

figures. It is possible that a closer correlation might have been obtained if the organic matter had been used instead of loss on ignition.

Acknowledgment.

The author wishes to thank Dr. Alun Roberts for help in the selection of suitable centres.

Summary.

1. The herbage of some typical North Welsh pastures has been analysed and compared.

2. The better quality pastures have a high phosphorus content; but the calcium content is rather lower than that for average cultivated pastures in Great Britain.

3. The poor pastures resemble in composition those of the Island of Lewis.

4. There is no marked correlation between the available P_2O_5 and CaO in the soil and the percentages of these constituents found in the herbage.

5. There is a suggestion of correlation between herbage P_2O_5 and available P_2O_5/ (loss on ignition).

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NATURAL CROSSING IN OATS.

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Introduction.

Apart from certain observations made by Jamieson (6) in Scotland on the occurrence and effect of natural crossing in oats, no information exists relating to the extent to which natural crossing in oats takes places in Britain. The oat plant is generally regarded as being normally closely self-fertilized, but in the literature on the subject evidence is being advanced which shows that in the United States of America (1, 2, 3, 5, 7); Canada (4); Norway (8) and other countries, natural crossing (or cross-pollination) in oats may occur with rather greater frequency than has hitherto been recognised. Varieties were found to differ appreciably in the readiness with which they are cross-pollinated. In certain instances natural crossing was observed to be of sufficiently marked frequency to command serious attention when critical genetical investigations are being pursued.

The importance to the farmer of the existence of a certain degree of natural crossing lies in its adverse influence upon the general purity of his " seed " sample. If he specializes in growing seed for sale rather than growing the crop for feeding

purposes, the necessity for occasional or periodic roguing of the crop will soon become apparent if pure seed stocks are to be maintained. In practice the frequency with which opportunity for natural crossing of an adverse character arises, will depend upon whether different varieties are grown alongside each other in relatively close contact, the compatibility of such varieties with regard to time of flowering and their inherent capacity for relative or absolute self-fertilization.

Any crossing, however, between plant and plant within a particular variety, provided that variety is pure to type, theoretically presents no adverse practical effects. When, on the other hand, varieties differing genetically are grown alongside each other over any considerable length of a field, adverse effects on purity through cross-pollination may appear.

The effects are readily apparent where varieties differ in such obvious characters as black and white colour of grain, or spreading as contrasted with one-sided type of panicle. They are less noticeable, however, but none the less real and detrimental, when the varieties do not differ in prominently marked characteristics.

In farm practice, a single variety is generally grown over a relatively large area and only very infrequently in close situation to another variety. Under such conditions the chances of adverse cross-pollination are very remote. To the grower, therefore, who deals with relatively large areas of but one or two varieties, the incidence of a small degree of natural crossing is not likely to be a serious source of seed contamination. Mechanical admixture arising through sowing, harvesting, storing or threshing operations is in general the more likely source of such contamination as may be found to exist.

To the plant breeder, on the other hand, who deals with numerous distinct strains, and develops these in small and often closely adjacent drills or plots, the prevalence of even a small degree of natural crossing can become a very hampering element. This is especially true in the process of raising new stocks of seed on a head-to-row basis from single head selections, whether in the process of pure lining old varieties or in developing strains of new varieties raised by controlled hybridization. It is obviously, therefore, of much importance to the plant breeder to know something of the extent, if any, to which natural crossing takes place and particularly of its presence or absence under the conditions of his own experimental grounds. Following the appearance of naturally crossed plants in the breeding nurseries of the Welsh Plant Breeding Station farm, it was decided in the

spring of 1925, by appropriately arranged drills and plots, to endeavour to collect data upon its frequency and relative extent.

Methods and materials.

The methods of experimentation adopted were not the same throughout the whole period of the investigation. In the seasons 1925 and 1926 the method followed was similar to that employed by Stanton and Coffman (7). Varieties were chosen in pairs on a basis of similarity in time of flowering and dissimilarity of grain colour (e.g. black and white colour of grain). Single heads were taken, the seed removed and sown side by side on a head-to-row basis in drills five feet long and one foot apart. First the seed from a head of a white variety, then the seed from a black variety until a series of head-rows of white alternating with head-rows of black were sown. By this method of layout the extent of inter-row cross-pollinations can be determined. When a floret of a white-grained variety is pollinated by pollen from a neighbouring drill of black-grained plants, the fertilized grain arising therefrom will in the following season give rise to a hybrid plant bearing grain of black colour (black being dominant to white). To make certain, however, that such a plant is a true hybrid black plant and not a rogue occurring through admixture it is necessary to harvest carefully all such plants and sow the seed obtained therefrom the succeeding year in order to observe their breeding behaviour. The segregation of white-grained plants in this season is taken as evidence of natural hybridity.

The method as outlined requires three seasons in order to complete the investigation. In the first season the pairs of varieties are sown in a series of head-row drills. In the second, the whole, or a proportionate part of the grain from each head-row of the white variety, is sown in separate drill-plots and an examination is made at harvest for hybrid black-grained plants. In the third season the grain from the observed black-grained plants is sown as spaced single grains and the presence or absence of segregation noted.

In order to arrive at an exact determination of the percentage natural crossing, the seed from the individual head-rows of the white variety should be sown as spaced single grains in the second season to permit a count of the individual plants being made at harvest time. Owing, however, to limitations of space and the amount of labour entailed this could not be done in the present investigation. The seed in the second season was therefore sown in drill-plots at a measured weight of seed

for each drill. As far as space permitted all the seed resulting from each separate head-row of the white member of each pair was sown, and the approximate number of plants raised was determined by making counts of representative sample lengths of the drill plots. From the average figure so derived the total number of plants for each plot was estimated. The head-rows of the black varieties were discontinued after the first season, the observations on natural crossing being confined to the head-rows of the white varieties.

Slight modifications of the above procedure were introduced in 1927 and the two subsequent seasons. Instead of sowing the alternate drills with seed derived from a single head, they were sown with carefully selected bulk seed of the respective varieties. This permitted sowings to be made at a heavier seed rate and gave rise to denser plant establishments. This change was introduced owing to the poor establishments which resulted from head-to-row sowings in 1926.

In addition to the method of sowing blacks and whites in alternate drills, a series of plots were laid down in the seasons 1926, 1928 and 1929 with seed prepared by thoroughly mixing equal weights of suitably paired black and white grained varieties. This mixed seed was then sown at a measured rate for each plot. These plots were made up of five or more drills arranged side by side, the drills being five feet long and one foot apart. At harvest time the produce of these plots was separated into its black and white components, the former were discarded and the latter threshed and used for sowing in the following season as in the "alternate drill" series, when observations were made for the appearance of hybrid black grained plants.

The "mixed seed" method of lay-out was employed in order to determine whether natural crossing would occur more frequently under the closer conditions prevailing between the black and white members in this lay-out than under the somewhat more widely separated conditions of the "alternate drill" series.

The varieties studied in these experiments were, in the main, cultivated forms of *A.sativa*, such as Scotch Potato, Victory, Record, Yielder, Radnorshire Sprig, Black Tartar and Black Bell III. Other members of this species used and less commonly cultivated were Orion, Nigra, Kösthavre, Avoine Noire and Garton's Early. The remaining varieties belonged to the species *A.sterilis culta* (Red Algerian, Early Ripe and Red Rustproof), *A.nuda*, *A.brevis* and *A.strigosa*. In the tables where the

TABLE I.

"Alternate-drill" series, showing summarized procedure and data relating to the five seasons, 1925-29, inclusive.

Varieties Paired.	*No. of head-rows or 5' rows.*	*General plant establishments.*	*Commencing panicle exsertion.*	*Amount of seed sown.*	*No. of separate plots.*	*Total No. of 5' drills (all plots).*	*Number of black-grained plants.*	*Behaviour of black-grained panicles in respect of colour of grain.*	***Equivalent in terms of no. of naturally crossed plants per acre.****
Season 1925.						**Succeeding**	**season.**	**Succeeding season.**	
A. brevis (white) .... Do. (dark grey)	10 10	F. good F. good	June 18 June 18	All All	10	19	None		
Red Algerian .... Orion	10 10	Thin Good	June 21 June 19	All —	8 (2 poor & disctd.)	13	1 in plot 8	Segregated into blacks and non-blacks.	670
Yielder .... Radnorshire Sprig	10 10	V. good V. good	June 27 June 26	Part —	9 (1 disctd)	42	None		
Victory .... Black Bell III	10 10	V. good V. good	July 3 July 5	Part —	10	50	1 in plot 1	Segregated into blacks and whites.	174
Potato .... Black Tartar	10 10	V. good V. good	July 5 July 5	Part —	10	50	1 in plot 3	Segregated into blacks and whites.	174
A. strigosa (white) .... Do. (dark grey) .	10 10	Good Good	July 3 July 10	Discontin	ued owing	to unsuitab	le pairing.		
Record .... Black Norway	10 10	V. fair V. fair	July 7 July 8	All —	10	22	2 in plot 9	Bred true.	
Total : 7 pairs	140				57	196	5	3 segregated.	133
Season 1926.									
A. brevis (white) .... Do. (dark grey)	10 10	R. poor R. poor	June 26 June 26	All	4	4	1 in plot 3	Bred true.	
Red Algerian .... Orion	10 10	R. poor Moderate	June 26 June 23	All	5	5	None		
Yielder .... Radnorshire Sprig	10 10	Poor Poor	July 2 July 5	None					
Victory .... Black Bell III	10 10	Poor Poor	July 5 July 6	None					
Potato .... Black Tartar	10 10	Moderate Moderate	July 7 July 7	All	8	22	None		
Record .... Black Norway	10 10	Some F. good Some F. good	July 7 July 8	All	7	9	None		
Total : 7 pairs	140			All	24	40	1	None segregated.	
Season 1927.									
Early Ripe................ Orion	8 8	V. thin V. thin	June 17 June 20	All —	8 —	9 —	1 in plot 3 2 in plot 4	3 segregated.	2,908
A. nuda .... Nigra	8 8	V. thin V. thin	June 20 June 24	All —	8 —	9 —	None		
Potato .... Black Tartar	8 8	V. thin V. thin	July 4 July 4	All —	8 —	36 —	None —		
Record .... Black Norway	8 8	V. thin Thin	July 4 July 6	All —	8 —	17 —	None —		
Total : 4 pairs	64			All	32	71	3	3 segregated.	368
Season 1928.									
Garton's Early .... Orion	5 5	V. good V. good	June 14 June 14	All —	** 4 —	33 —	10 in plot 2 1 in plot 3 1 in plot 4	4 bred true (ex plot 2) 8 segregated.	2,112
Mulga .... Orion	5 5	V. poor V. good	June 14 June 19	Discontinued	owing	to poor	seedling esta	blishment.	
Red Rustproof .... Avoine Noire	5 5	V. good V. good	June 17 June 17	All —	5 —	28 —	4 in plot 3 2 in plot 4 1 in plot 5	All bred true.	
A. brevis (white) .... Do. (dark grey)	5 5	V. good V. good	June 19 June 16	All —	5 —	42 —	None —		
Victory .... Black Bell III	5 5	V. good V. good	June 28 June 29	All —	5 —	30 —	1 in plot 3 2 in plot 4 1 in plot 5	All 4 segregated.	1,160
Scotch Potato .... Black Tartar	5 5	V. good V. good	June 29 June 30	All —	5 —	44 —	1 in plot 5	Bred true.	
Total : 5 pairs	50			All	24	177	24	12 segregated.	588
Season 1929.									
Garton's Early .... Orion	5 5	Good Good	June 25 June 25	All —	5 —	57 —	1 in plot 1 1 in plot 3 2 in plot 5	3 segregated; 1 bred true (ex plot 5).	459
Potato .... Black Tartar	5 5	Good Good	July 9 July 10	All —	5 —	50 —	1 in plot 1	Bred true (pure Black Tartar).	
Kösthavre .... Black Bell III	5 5	F. good F. good	July 12 July 11	All —	5 —	43 —	None —		
Total : 3 pairs	30			All	15	150	5	3 segregated.	174
Sum total					152	634	38	21 segregated	290

* Estimated on a basis of 9,712 five-foot drills to an acre.
** Seed of one lot damaged by mice.

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varieties are listed in pairs, the white-grained variety is in all cases given first, followed by the varietal name of the black-grained member.

Varieties were chosen according to time of flowering in such a manner as to give pairs of varieties flowering at different dates, that is, at early, medium and late flowering periods. This arrangement enabled the data to be examined in relation to the time of flowering as well as in respect of the general frequency of natural crossing.

All the trials were laid down in the spring of each season.

Experimental data.

The " Alternate-drill " Series.

In the " alternate-drill " series of trials several pairs of varieties were tested; one pair was repeatedly used in all five seasons while others were grown in only one, two or three seasons. The more important observations and data relative to these trials are set out in tabulated form in Table I. For each of the five seasons details of the varieties tested, the procedure in the second and subsequent season, and the number of natural hybrids observed are separately shown.

Season 1925.

In this season seven pairs of varieties were grown. General plant establishments on the whole were good, although many rows of the variety Red Algerian were rather thin. With the exception of the *A.strigosa* pair, all lots matched up very closely in respect of panicle exsertion and time of flowering.

Panicle exsertion in this season ranged from June 18th to July 10th, giving a difference of three weeks between the earliest and the latest variety. It was found that the anthers of the uppermost spikelet of the panicle generally dehisced within from six to eight days from the time of its emergence through the leaf sheath, that is, from the date of what is recorded in Table I as the " commencement of panicle exsertion." The maximum flowering condition was reached a few days later.

Separate progeny plots were grown the succeeding year from all the head-rows of the white varieties with the exception of *A.strigosa* (white) which was not suitably matched, two poorly established rows of Red Algerian and one row of Yielder. In the case of *A.brevis*, Red Algerian and Record all available seed was sown, while a proportionate part of the seed from each head-row was sown of the varieties Yielder, Victory and Scotch Potato. Altogether the plots comprised 196 five-foot drills, and

five black-grained plants were found and removed at harvest time. Three of the latter in the following year showed segregation for grain colour and were, therefore, regarded as natural hybrids, two bred true and were considered to be rogues. The former were from plots of Red Algerian, Victory and Scotch Potato. No natural hybrids were observed in the progeny plots of *A.brevis*, Yielder and Record. The average extent of natural crossing represents one hybrid plant in every 65 drills raised from head-rows of the white-grained varieties, or on an area basis, an average equivalent to 133 hybrid plants per acre.

Season 1926.

The same pairs of varieties with the omission of *A.strigosa* were again set up on a head-to-row basis in 1926. In this season establishments were poor, brairding being thin and very patchy in nearly all the lots. Progeny plots were grown from only 24 of the 70 white-grained head-rows, the remainder being discarded owing to the unsatisfactory nature of the establishments. One black-grained plant was found in a plot of *A.brevis* (white) but none in plots of the other varieties. The black-grained *A.brevis* plant in the next season was observed to breed true and was therefore not the offspring of a natural cross. The absence of any naturally crossed plants in this set of experiments was attributed to the poor seedling establishment in the paired drills in 1926 and the consequent lack of proximity between the plants of neighbouring drills. That it was not due to any seasonal effect was shown by the occurrence of naturally crossed plants in the plots of the " mixed seed " series growing alongside and sown at the same date.

Season 1927.

In the 1927 tests changes were made in the varieties used. The Potato-Black Tartar and Record-Black Norway pairs were continued, but the others were displaced by Early Ripe-Orion and *A.nuda-Nigra*. Although the drills in this season were sown with a weighed amount of seed for each, instead of the restricted amount of seed provided by a single head, establishments were nevertheless thin and somewhat unsatisfactory. As shown in Table I, all the grain from each head-row of the white varieties was sown in separate plots in the succeeding year. All bred true for white colour of grain with the exception of two head-row progenies of the variety Early Ripe from which three black-grained plants were removed, one from plot 3 and two from plot 4. These three plants segregated for colour of grain in the

following season. The ratio of black-grained plants to the total number of 5-foot drills for 1927 represents an average of one to approximately 24 drills, which is more than two and a half times that found in 1925, and is equivalent to 368 plants to the acre.

Season 1928.

Six pairs of varieties were laid down in 1928 but the number of drills was restricted to five for each variety (ten per pair). With the exception of the Mulga-Orion drills, establishments were very good and matching up at the time of heading was quite satisfactory. In this season heading dates were, in general, about a week earlier than in preceding seasons. The number of natural crossings which took place was higher than in former years, there being a total of four in three of the five plots derived from the Victory-Black Bell III pair, and six in three plots of Garton's Early, which had been paired with Orion. Other black-grained plants were obtained but their breeding behaviour showed them to be rogues and not natural hybrids. No natural crossing occurred in plots of Red Rustproof, *A. brevis* and Scotch Potato. The extent of natural crossing for this season was approximately one hybrid in 18 drills, an average equal to 588 plants per acre. This was the highest proportion obtained in the whole of the "alternate-drill" series.

Season 1929.

Only three pairs were tested in 1929, two were late and one was early in ripening. Scotch Potato was paired with Black Tartar, Kösthavre with Black Bell III, and Garton's Early with Orion. Establishments were good and the pairs were well matched with regard to time of heading. In the succeeding year one black-grained plant was found in a plot of Scotch Potato and four in three plots of Garton's Early. The former bred true. Three of the four plants of Garton's Early segregated and were definitely natural hybrids, this being the only variety showing natural crossing in this season. The general ratio for 1929 was one natural hybrid to 50 drills, or a proportion equal to 174 plants per acre.

Taking the "alternate-drill" series as a whole, a total of 21 segregating black-grained plants was obtained, or the equivalent of an average of 290 to an acre.

The "mixed-seed" series.

In the "mixed seed" series separate tests were conducted in the three seasons 1926, 1928 and 1929 and the summarized results are given in Table II.

TABLE II.

"Mixed seed" series, showing summarized procedure and data relating to the three seasons, 1926, 1928, and 1929, respectively.

Varieties sown mixed.	*No. of 5 ft. rows sown.*	*General plant establishments.*	*Commencing panicle exsertion.*	*Amount of seed sown.*	*Total No. of 5 ft. rows sown.*	*Number of black-grained plants.*	*Behaviour of black-grained plants in respect of grain colour.*	*Equivalent in terms of no. of hybrid plants per acre.*
Season 1926.				*Succeeding*	*Season.*		*Succeeding Season.*	
Early Ripe / Orion	5	Good	June 18	All white grain	6	3	All 3 segregated.	4,356
A. brevis (white) / dark grey	5	F. good	June 23	All white grain	10	None		—
Victory / Black Bell III	5	Good	June 29	All white grain	13	9	8 bred true ; 1 segregated.	670
Potato / Black Tartar	5	Good	July 3	All white grain	10	None		—
Record / Black Norway	5	F. good	July 5	All white grain	5	None		—
Total : 5 pairs	25			All	44	12	4 segregated.	792
Season 1928.								
Garton's Early / Orion	10	V. good	June 14	All white grain	64	8	6 segregated ; 2 bred true.	816
Red Rustproof / Avoine Noire	10	Good	June 14	All white grain	14	2	Both bred true.	—
Victory / Black Bell III	10	Good	June 30	All white grain	60	6	5 segregated ; 1 bred true.	725
Potato / Black Tartar	10	V. good	June 30	All white grain	50	None		—
Total : 4 pairs	40			All	188	16	11 segregated.	506
Season 1929.								
Garton's Early / Orion	5	Good	June 25	All white grain	40	4	All 4 segregated.	872
Potato / Black Tartar	5	S. thin	July 10	All white grain	30	None		—
Kosthavre / Black Bell III	5	S. thin	July 12	All white grain	30	3	All 3 segregated.	870
Total : 3 pairs	15			All	100	7	7 segregated.	609
Sum total	80				332	35	22 segregated	576

Season 1926.

Five pairs of varieties were sown in 1926 in small five-drill plots, two early, one medium-early and two late ripening pairs. Unlike the " alternate-drill " series sown this season, plant establishments were reasonably good. Exsertion dates for the individual members of each pair were not separately ascertained and the date of the commencement of panicle exsertion shown in the table applies to the plot in general. Comparisons with observations in the " alternate-drill " series show that the varieties sown in the " mixed seed " plots were reasonably well matched in respect of time of heading. In the progeny plots raised of the separated white-grained members of each mixed plot twelve black-grained plants were observed, three in the plot of Early Ripe and nine in the Victory plot. Eight of the latter were later demonstrated to breed true and were therefore not products of natural crossing. No natural hybrids were present in plots of Scotch Potato and Red Rustproof. This gives a total of four natural hybrids in 44 drills, which is equal to 492 plants per acre.

Season 1928.

In 1928 four pairs were tested in plots double the size of those employed in 1926. Establishments were satisfactory and, as in the " alternate-drill " series alongside, heading commenced at an earlier date than in former seasons. Black-grained plants were found in the progeny plots of three pairs, but those found in the plot of Red Rustproof were later shown to breed true, thereby reducing natural crossing to only two of the pairs of varieties. Six black plants were found in Victory and eight were removed from Garton's Early. Of the former, five, and of the latter, six, showed segregation and were obviously natural hybrids. No naturally crossed plants were found in plots of Red Rustproof and Scotch Potato. This gives a total of eleven hybrids in 188 drills, or an average equal to 506 plants per acre.

Season 1929.

In the third and last season three pairs were tested, one early and two late in ripening. Plant establishments were moderately good and heading dates were about a week later than in the 1926 season. In 1930 three black-grained plants were found in the progeny plot of the Kösthavre-Black Bell III pair, and four in the corresponding plot of Garton's Early-Orion. These in the breeding tests conducted in 1931 all showed segregation and were regarded as natural hybrids. No naturally

crossed plants were found in plots of Scotch Potato. The total number of cross-fertilized plants in this season was seven in 100 drills, or a proportion equal to 609 plants per acre.

All told, the "mixed seed" series gave 22 hybrid black-grained plants, or an average equal to 576 plants per acre.

Discussion of Results.

The data presented in Tables I and II show very clearly that under the conditions prevailing in these experiments natural crossing is of very definite occurrence. Its presence is apparent in each of the five seasons during which the trials were conducted. In its frequency and distribution inherent differences between varieties appear to play an important part, for some varieties seem to be more susceptible than others. This is readily seen in Table III where the re-arranged data are brought together in a condensed form and the varieties listed in the order of relative earliness to ripen. In this table the degree of natural crossing is, for convenience of comparison, given as a percentage amount for each variety.

Comparing in a general way the influence of earliness and lateness on natural crossing, members of the early group show a definitely higher proportion of natural crosses than the lates, namely, 0.09 and 0.33 per cent., as against 0.003 and 0.034 and 0.059 per cent. respectively. In both groups, however, there are varieties which show a complete freedom from cross-pollination. In the medium-early group only one natural hybrid was obtained, while three of the four varieties show complete absence of natural crossing. The numbers here are small and some caution is needed in making generalizations between or within the groups. Further, the groups, it will be observed, are differently constituted, inasmuch as the early and medium-early groups each contain representative varieties of three different species whereas the members of the late group all belong to the commonly cultivated species *A.sativa.* According to observations made by Griffee and Hayes (8), Garber and Quisenberry (1) and others, varieties of *A.sterilis culta* are prone to exhibit a greater susceptibility to natural crossing than varieties of *A.sativa.* It may therefore on this account be misleading to compare Early Ripe, for instance, with Victory or Scotch Potato in order to make deductions as to the influence of time of ripening on the degree of natural crossing. We may, however, compare Garton's Early with Victory (both being members of *A.sativa*) and in this case although the early variety shows the higher degree of natural crossing the difference is not so marked as that

TABLE III.

Summary of natural crossing data, showing percentage figures for each variety, 1925-29, inclusive. The varieties are listed in the order of earliness to ripen.

VARIETY.*	"ALTERNATE DRILL" SERIES.															"MIXED SEED" SERIES.											
	1925.			1926.			1927.			1928.			1929.				1926.			1928.			1929.				
	No. of Plants.	*Observed Natural Crosses.*	*Percentage.*	*No. of Plants.*	*Observed Natural Crosses.*	*Percentage.*	*No. of Plants.*	*Observed Natural Crosses.*	*Percentage.*	*No. of Plants.*	*Observed Natural Crosses.*	*Percentage.*	*No. of Plants.*	*Observed Natural Crosses.*	*Percentage.*	*Percentage all Trials.*	*No. of Plants.*	*Observed Natural Crosses.*	*Percentage.*	*No. of Plants.*	*Observed Natural Crosses.*	*Percentage.*	*No. of Plants.*	*Observed Natural Crosses.*	*Percentage.*	*Percentage all Trials.*	*Percentage all Trials (both series).*	*Average Group Percentage.*
RLY.																												
. *brevis (white)*, (*A. brevis (black)*)	2,280	Nil	Nil	480	Nil	Nil	—	—	—	5,040	Nil	Nil	—	—	—	Nil	1,200	Nil	Nil	—	—	—	—	—	—	Nil	Nil	0.079
urly Ripe (Orion)	—	—	—	—	—	—	1,083	3	0.28	—	—	—	—	—	—	0.28	720	3	0.42	—	—	—	—	—	—	0.417	0.33	
arton's Early (Orion)	—	—	—	—	—	—	—	—	—	3,960	8	0.202	6,840	3	0.044	0.102	—	—	—	7,680	6	0.077	4,800	4	0.083	0.080	0.090	
DIUM EARLY.																												
. *nuda* (Nigra)	—	—	—	—	—	—	1,080	Nil	Nil	—	—	—	—	—	—	Nil	—	—	—	—	—	—	—	—	—	—	Nil	0.005
ed Algerian (Orion)	1,560	1	0.064	600	Nil	Nil	—	—	—	—	—	—	—	—	—	0.046	—	—	—	—	—	—	—	—	—	—	0.046	
ed Rustproof (Avoine Noire)	—	—	—	—	—	—	—	—	—	3,360	Nil	Nil	—	—	—	Nil	—	—	—	1,680	Nil	Nil	—	—	—	Nil	Nil	
ielder (Radnorshire Sprig)	5,040	Nil	Nil	Failed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Nil	
E.																												
ctory (Black Bell III)	6,000	1	0.017	Failed	—	—	—	—	—	3,600	4	0.111	—	—	—	0.052	1,560	1	0.064	7,200	5	0.069	—	—	—	0.068	0.059	0.022
otch Potato (Black Tartar)	6,000	1	0.017	2,640	Nil	Nil	4,320	Nil	Nil	5,280	Nil	Nil	6,000	Nil	Nil	0.004	1,200	Nil	Nil	6,000	Nil	Nil	3,600	Nil	Nil	Nil	0.003	
ecord (Black Norway)	2,640	Nil	Nil	1,080	Nil	Nil	2,040	Nil	Nil	—	—	—	—	—	—	Nil	600	Nil	Nil	—	—	—	—	—	—	Nil	Nil	
esthavre (Black Bell III)	—	—	—	—	—	—	—	—	—	—	—	—	5,160	Nil	Nil	Nil	—	—	—	—	—	—	3,600	3	0.083	0.083	0.034	
n and Total Averages of all arieties	23,520	3	0.013	4,800	—	Nil	8,520	3	0.035	21,240	12	0.056	18,000	3	0.017	0.027	5,280	4	0.076	22,560	11	0.049	12,000	7	0.058	0.055	0.037	—
n and Total Averages, omitting ieties which show no natural ssing	—	—	0.022	—	—	Nil	—	—	0.28	—	—	0.16	—	—	0.044	0.044	—	—	0.17	—	—	0.074	—	—	0.083	0.086	0.058	—

* The black-grained variety with which the white variety was paired is shown in brackets.

ce page 124.

crossed plants were found in plots of Scotch Potato. The total number of cross-fertilized plants in this season was seven in 100 drills, or a proportion equal to 609 plants per acre.

All told, the "mixed seed" series gave 22 hybrid black-grained plants, or an average equal to 576 plants per acre.

ripe, for instance, with Victory or Scotch Potato in order to make deductions as to the influence of time of ripening on the degree of natural crossing. We may, however, compare Garton's Early with Victory (both being members of *A.sativa*) and in this case although the early variety shows the higher degree of natural crossing the difference is not so marked as that

between Early Ripe and Victory. Seasonal influences and differences due to time of flowering cannot, however, be disregarded in this connection. Before commenting on these it would be well to consider rather more critically the significance of the observations for the individual varieties.

As far as those varieties which show some degree of natural crossing are concerned there is little to state except that the data on the whole may be regarded as representing approximately the average amount of crossing which under the experimental conditions would take place. On the other hand, in connection with those varieties which show a complete absence of natural crossing, possible inherent limitations in the nature of the experiments must be examined if a right interpretation of the results is to be arrived at.

There arises here the question whether the absence of natural crossing in these varieties is due to inherent freedom from susceptibility to cross-pollination or to restricted pollen dispersion or some such cause on the part of the black varieties with which they were individually paired. On reference to Table III it will be observed that where Orion has been used as the black-grained member of a pair, a certain amount of natural crossing has in all cases occurred. The same is true of Black Bell III, but not of the other black-grained varieties. It seems, therefore, open to doubt whether the absence of natural crossing in these varieties is due to some inherent floral mechanism or floret behaviour which invariably ensures self-fertilization, or whether it is a case of the absence of pollen in sufficient degree or at the right time to permit cross-pollination to take place. This ambiguity arising out of possible limitations on the part of the variety selected as pollinating parent was not foreseen when these experiments were begun. It arises, therefore, as a matter for further investigation. It is a problem which could readily be tested by comparing relative cross-pollination in Red Algerian and Red Rustproof when paired with Orion on the one hand and Avoine Noire on the other. Also by pairing Victory, Potato and Record with Black Bell III and Black Tartar respectively. Space and labour are limiting factors in the conduct of an investigation of this kind, but some further data are definitely needed to enable a conclusive interpretation to be made.[1]

The meteorological conditions experienced during the flowering periods in the seasons under review are presented in Table IV. In a general way it will be observed that in the matter of

[1] It is proposed to begin a limited series of trials along the lines indicated with Potato, Record and Victory in the present season (1938).

maximum and minimum temperatures variations from season to season for the June and July periods fluctuate rather less than do the differences between the June and July periods within each season. As far, therefore, as the early and late ripening varieties are respectively concerned, the seasonal influences do not vary together over the whole flowering period, and on the average slightly higher temperatures prevail for the late flowering types. The accumulated temperature is also higher during the period when the late varieties are in flower. Early and late varieties, therefore, flower each season under slightly different temperature conditions.

Owing to the generally low degree of natural crossing present and the somewhat high fluctuations between variety and variety it is not possible to trace with some degree of consistency any definite influence of season on the amount of crossing which appeared. The difficulty of doing so is increased by changes made in the varieties under study from season to season and the low degree of crossing or its complete absence in those varieties which were included in three or more tests. Thus Scotch Potato, which was included in all the trials, is valueless, as it gave no natural hybrids except in the " alternate-drill " series in 1925, when just one hybrid plant was obtained.

The influence of the two methods of lay-out adopted in the investigations upon the extent of natural crossing is perhaps best studied by comparing just those varieties which were common to both series and which have fairly consistently exhibited some degree of natural crossing. The observations relating to these are separately shown in Table V. The percentage figures for the two methods are 0.088 and 0.087 in " alternate-drills " and " mixed seed " respectively. These agree very closely and indicate that under the prevailing conditions of these tests natural crossing was as readily effected between members of adjacent drills as between individual plants within the same drill.

Table V also serves to emphasise the fact that in respect of the eleven white varieties tested in these investigations, thirty-eight of the forty-three natural hybrids obtained were found in the three varieties listed in this Table, namely, Early Ripe, Garton's Early and Victory.

Viewing the results as a whole, however, the percentage figures in the " mixed seed " series (see Table III) show decidedly less fluctuation than those in the " alternate drill " lay-out.

In their account of studies of natural crossing in oats at Akron, Stanton and Coffman (7) have pointed out that the actual

TABLE IV.

Meteorological records relating to the flowering periods during the seasons 1925-29 respectively.

JUNE

	Year.	18	19	20	21	22	23	24	25	26	27	28	29	30	Average.
Maximum Temperature	1925	58	59	60	58	59	62	64	64	55	62	61	68	70	61.5
	1926	59	61	65	56	58	56	56	56	58	60	64	66	60	60.0
	1927	58	57	57	57	57	54	55	54	53	52	56	57	63	56.1
	1928	56	61	56	60	60	58	59	60	57	56	56	56	56	58.0
	1929	62	63	58	58	56	58	55	58	59	63	64	64	63	60.0
Average		58.6	60.2	59.2	57.8	58.0	57.6	57.8	58.4	56.4	58.6	60.0	60.2	61.2	59.1
Minimum Temperature	1925	50	41	49	52	41	44	45	45	45	50	48	46	49	46.4
	1926	52	49	54	54	51	49	46	41	41	45	45	51	53	48.5
	1927	52	50	50	51	48	49	50	49	44	45	49	43	50	48.5
	1928	49	50	49	45	45	51	51	50	52	48	51	53	48	49.4
	1920	44	51	53	46	49	53	59	39	40	45	46	46	45	46.7
Average		49.4	48.2	51.0	49.6	46.8	49.2	48.4	44.8	44.4	46.6	47.4	47.8	49.0	47.9
Accumulated Temperature ...	1925	11	8	13	12	8	11	13	13	8	13	11	15	17	11.7
	1926	13	13	17	13	13	11	9	7	8	11	13	17	19	12.6
	1927	13	11	11	12	11	9	11	9	7	7	11	8	15	10.4
	1928	11	13	11	11	11	13	13	13	13	10	11	13	10	11.7
	1929	11	15	13	10	11	13	11	7	8	12	14	13	12	11.5
Average		12.0	12.0	11.0	11.6	10.8	11.4	11.4	9.8	8.8	10.6	12.0	13.2	14.6	11.6
Precipitation	1925	Nil	Nil	Tr.	Nil	Nil	Nil	Nil	0.01	Tr.	Nil	Nil	Nil	0.01	0.002
	1926	Tr.	0.05	0.01	0.14	0.01	0.08	0.02	Nil	Nil	Nil	Nil	Nil	Nil	0.024
	1927	1.22	0.05	0.40	0.01	0.28	0.62	0.01	0.65	0.14	0.01	0.12	0.03	0.44	0.306
	1928	0.13	0.01	0.13	0.01	Nil	Nil	0.01	0.57	0.11	0.03	1.39	0.67	0.01	0.236
	1929	Nil	0.03	Nil	0.38	0.46	Nil	Nil	Tr.	Nil	Nil	Nil	Nil	Nil	0.067
Average		0.27	0.03	0.11	0.11	0.15	0.14	0.01	0.15	0.05	0.01	0.30	0.14	0.09	0.127
Relative Humidity	1925	72	Missing	98	67	75	79	88	75	98	67	93	78	70	80.0
	1926	92	90	95	99	73	62	59	65	71	77	71	65	63	75.5
	1927	96	90	93	84	83	80	90	99	79	81	81	81	88	86.5
	1928	96	97	81	94	80	85	68	90	94	81	96	86	83	87.0
	1929	76	77	64	60	99	71	72	70	74	73	70	59	60	71.1
Average		86.4	88.5	86.2	80.8	82.0	75.4	75.4	79.8	83.2	75.8	82.2	73.8	73.0	80.0
Sunshine	1925	12.1	13.2	2.2	8.1	13.4	11.5	12.5	13.7	0.6	9.1	12.0	9.6	7.9	9.7
	1926	4.9	8.3	Nil	Tr.	6.9	13.0	11.2	15.1	7.7	12.6	10.7	15.1	7.6	8.7
	1927	2.8	4.4	1.4	4.4	6.2	2.2	1.2	0.3	3.2	Nil	3.9	0.1	1.5	2.4
	1928	0.3	2.7	11.5	Nil	11.8	10.0	9.0	0.8	0.5	3.4	Nil	1.9	8.9	4.7
	1929	13.1	10.0	9.7	7.9	13.8	Nil	9.6	9.0	Nil	15.1	13.0	11.0	12.3	9.6
Average		6.6	7.7	5.0	4.1	10.4	7.3	8.7	8.0	2.4	8.0	7.9	7.5	7.6	7.0
Wind Velocity	1925	18	2	4	18	12	3	18	14	13	16	0	3	1	9.4
	1926	0	0	0	1	1	5	10	0	2	0	0	0	0	1.5
	1927			No records taken.			Anemobiograph out of order.								
	1929	16	14	15	23	24	20	12	18	30	20	30	18	26	20.5
	1929	10	10	17	16	16	18	20	15	10	10	10	14	13	13.7
Average		11.0	6.5	9.0	14.5	13.2	11.5	15.0	12.0	14.0	11.5	10.0	9.0	10.0	11.2

JULY.

	Year.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Average.
Maximum Temperature	1925	66	74	68	68	61	62	60	60	58	62	65	67	67	67	63	63	65	62	66	72	64.8
	1926	70	74	70	73	56	61	64	65	62	62	68	76	82	76	72	72	75	67	63	63	68.6
	1927	60	62	63	64	62	64	64	68	65	60	59	66	67	67	65	66	65	66	67	64	64.2
	1928	59	58	58	58	58	57	61	61	63	65	66	63	64	64	64	63	64	62	62	63	61.6
	1929	58	62	64	63	57	58	58	60	59	63	73	65	70	73	79	73	69	63	69	70	65.3
Average		61.3	65.0	61.6	65.0	58.8	60.4	60.1	62.8	60.1	62.4	66.2	67.4	70.0	69.4	67.4	80.4	67.8	64.0	65.4	66.4	64.9
Minimum Temperature	1925	41	54	54	55	49	53	52	49	49	52	56	56	54	52	55	56	55	52	51	52	52.3
	1926	51	58	53	54	53	52	53	54	57	55	57	62	61	63	61	56	60	63	56	54	54.8
	1927	52	52	50	57	55	53	53	52	56	58	55	55	57	57	55	52	50	50	57	58	54.1
	1928	52	51	52	46	50	52	51	52	52	49	55	52	55	53	52	56	49	49	57	56	52.2
	1920	44	49	52	55	58	49	50	41	50	53	57	54	49	54	59	62	54	54	55	51	52.1
Average		48.6	53.4	53.4	53.4	51.4	51.8	51.8	49.6	52.8	53.0	56.0	55.8	55.2	55.8	56.4	56.4	53.6	53.6	55.2	54.2	53.1
Accumulated Temperature ...	1925	15	22	19	19	14	15	14	13	11	15	19	19	19	17	17	17	19	15	17	20	16.7
	1926	20	24	19	21	13	15	17	17	17	17	21	27	29	17	25	22	25	23	17	17	20.6
	1927	14	15	15	19	17	17	18	18	19	16	15	19	20	20	18	17	15	16	20	19	17.8
	1928	13	14	13	10	12	13	14	15	15	15	19	15	17	17	16	17	15	13	17	17	14.8
	1929	9	13	16	17	11	11	12	9	13	16	23	17	17	21	27	25	19	17	20	19	20.6
Average		14.2	17.6	16.4	17.2	13.2	14.2	15.0	14.4	15.0	15.8	19.4	19.4	20.4	20.4	20.6	19.6	18.6	16.8	18.2	18.4	18.1
Precipitation	1925	0.01	0.14	Nil	Nil	Nil	0.36	Nil	0.01	0.30	0.02	Nil	0.01	0.01	Nil	0.07	0.08	0.16	0.09	0.04	0.05	0.07
	1926	Nil	Nil	Nil	0.05	0.31	0.21	0.01	0.05	Nil	0.16	0.02	Tr.	Nil	Nil	Nil	Nil	0.05	1.72	0.18	0.09	0.14
	1927	0.06	0.01	0.03	0.32	0.20	0.01	1.15	0.10	0.01	Tr.	0.09	0.05	1.21	0.01	Tr.	Nil	Nil	Nil	0.10	0.28	0.19
	1928	0.34	0.01	Tr.	1.45	0.34	0.01	Nil	0.25	0.01	Nil	Tr.	Nil	Nil	Nil	0.01	Nil	Nil	Nil	Nil	Nil	0.12
	1929	Nil	Nil	Nil	0.06	0.37	Nil	0.03	Nil	0.07	0.02	0.18	0.19	Nil	Nil	Nil	Nil	0.01	0.01	Nil	Nil	0.047
Average		0.08	0.03	0.01	0.38	0.24	0.12	0.24	0.08	0.08	0.04	0.06	0.05	0.24	0.002	0.02	0.02	0.04	0.36	0.06	0.08	0.113
Relative Humidity	1925	62	84	79	83	98	94	80	79	68	88	82	94	93	76	99	85	67	98	48	91	82.4
	1926	67	50	51	41	91	92	91	81	85	97	89	74	51	81	81	55	59	100	99	78	75.6
	1927	94	91	85	59	86	52	75	78	91	93	93	91	90	88	96	81	65	68	71	96	82.6
	1928	73	79	73	79	94	91	63	99	89	68	79	89	82	83	79	79	68	81	86	88	81.1
	1929	74	66	77	69	98	75	78	69	91	58	61	80	79	59	30	75	74	85	69	91	72.9
Average		74.0	73.8	73.0	66.2	93.4	80.8	77.4	81.2	84.8	80.8	80.8	85.6	79.0	77.4	77.0	75.0	66.6	86.4	74.6	88.8	78.9
Sunshine	1925	9.8	8.6	2.4	10.6	7.2	Tr.	9.3	3.7	1.7	4.1	7.9	0.8	8.6	7.3	Nil	0.7	3.2	8.7	7.2	9.5	5.6
	1926	13.4	13.9	6.1	8.5	Nil	Nil	8.0	5.0	8.1	0.7	0.5	10.1	12.9	10.6	3.0	9.3	7.3	0.5	0.2	8.0	6.3
	1927	2.1	6.1	3.6	3.7	6.5	4.1	1.1	8.6	6.7	0.5	Nil	0.7	0.4	1.6	9.8	8.1	15.2	14.4	0.2	0.3	4.7
	1928	0.6	7.6	10.7	4.8	1.0	0.4	14.5	Nil	8.5	4.5	6.0	9.5	11.8	13.4	11.9	12.6	14.3	11.8	0.8	3.2	7.4
	1929	2.9	1.4	2.9	5.0	5.7	7.2	5.7	11.6	Tr.	Nil	5.1	8.5	15.6	14.9	14.6	13.7	7.0	1.9	9.3	7.9	7.0
Average		5.8	7.5	5.1	6.5	4.1	2.3	7.7	5.8	5.0	2.0	3.9	5.9	9.8	9.5	7.8	8.8	9.4	7.9	3.5	5.8	6.2
Wind Velocity	1925	0	7	1	8	0	14	12	1	2	10	0	0	0	0	0	0	8	23	18	6	5.5
	1926	0	0	0	0	0	8	0	0	6	0	0	0	0	0	0	0	0	2	0	5	1.5
	1927																					
	1929	28	23	12	20	25	23	8	18	24	25	20	12	15	6	11	17	7	19	14	14	15.8
	1929	8	4	5	8	10	22	7	13	14	24	18	10	10	6	18	3	14	13	10	8	11.2
Average		9.0	8.5	4.5	9.0	9.0	15.0	7.0	4.0	11.5	15.0	9.5	5.5	6.2	3.0	7.2	5.0	7.2	12.0	10.5	8.2	8.5

Temperature = In degrees Fahrenheit.
Accumulated Temperature = 42° and above.
Precipitation = In inches.

Relative Humidity = At 3 p.m.
Sunshine = In hours.
Wind Velocity = Miles per hour (average between 12 noon and 4 p.m.).

maximum and minimum temperatures variations from season to season for the June and July periods fluctuate rather less than do the differences between the June and July periods within each season. As far, therefore, as the early and late ripening varieties are respectively concerned, the seasonal influences do not vary

degree of natural crossing which takes place within or between any given drills is twice that actually obtained by calculation based upon the appearance of the hybrid black-grained plants. This is explained on the basis that it is reasonable to assume that as black and white plants are associated in the tests in about equal numbers, there are equal chances of white being pollinated by pollen from an adjacent white plant as from an adjacent black

TABLE V.

A comparison of the frequency of natural crossing between the "alternate-drill" and "mixed seed" series of trials.

Variety.	*"Alternate-drill" series.*		*"Mixed-seed" series.*	
	No. of plants examined.	*No. of natural crosses.*	*No. of plants examined.*	*No. of natural crosses.*
Early Ripe ...	1,083	3	720	3
Garton's Early ...	10,800	11	12,480	10
Victory ...	9,600	5	8,760	6
Total ...	21,483	19	21,960	19
Percentage ...	0.088		0.087	

plant. In the observations, however, it is only the latter which are separated as natural hybrids; the former are generally indistinguishable from uncrossed whites and therefore cannot be taken into account.

A tabulated comparison of the results presented in the present paper with those obtained by investigators elsewhere is given in Table VI.

The figures for the varieties showing lowest and highest percentages respectively (columns 4 and 5) are seen to differ relatively widely as also do the figures which relate to the actual percentage of hybrid black-grained plants observed. The latter, however, have in all cases been calculated on the basis of the total number of plants studied and are thereby influenced by the presence or absence in the respective trials of varieties which show no natural crossing. The actual numbers of these are set forth in columns 6 and 7 of the table. After allowance is made for these differences the percentage figures for the Aberystwyth area are seen to be decidedly lower than those hitherto obtained abroad.

A more detailed examination of all the recorded data shows that the highest degree of natural crossing prevails in varieties of *A. sterilis culta* and some *A. nuda* members, while the varieties

which show least or no natural crossing most frequently belong to the species *A. sativa.* Varieties of the latter species as a whole flower rather later than do members of *A. sterilis culta.* These,

TABLE VI.

Showing percentage natural crossing in oats at different geographical centres.

Place.	*Investigators.*	*Per cent. black-grained hybrids.*	*Varietal percentages.*		*No. of varieties studied.*	*No. of varieties showing natural crossing.*	*No. of plants.*
			Lowest.	*Highest*			
Akron, Colorado, U.S.A.	Stanton and Coffman.	0.36	0.10	0.97	4	4	10,627
St. Paul, Minnesota, U.S.A.	Griffee and Hayes.	0.37	0.04	1.40	5	5	46,836
Morgantown, W.Virginia U.S.A.	Garber and Quisenberry	0.085	0.08	0.41	7	2	9,450
do.	Garber and Hoover.	0.51	—	—	1	1	11,864
Hedmark, Norway.	Wexelsen.	0.28	0.05	2.98	—	—	10,668
Saskatoon, Canada.	Harrington.	0.16	0.06	0.69	3	2	27,017
Aberystwyth, Wales.	Present writer.	0.037	0.003	0.33	11	6	115,920

under conditions at Aberystwyth, flower generally round about or shortly after the time when the days are longest, whereas medium-late varieties like Victory, Potato and Record flower later and under conditions generally of slightly higher average temperatures. This was true at least of the seasons 1925-1929 inclusive. The evidence nevertheless seems to indicate that the differences between the members of the two species are probably inherent and genetical, but whether the time at which flowering takes place has any accentuating effect upon the frequency of natural crossing cannot be decided from the data so far assembled.

Considering the data presented in this paper from the view-point of their significance in relation to the problem of raising pure line stocks of seed, it is necessary to examine the figures from a somewhat different angle, namely, that of the frequency with which cross-pollination occurs between one head-row drill and its neighbour, for it is the extent of crossing of this kind rather than the percentage crossing which affects the absolute purity of the head-rows as initial stocks. Referring to Table I the numbers of head-rows subjected to the possibility of cross-pollination by neighbouring drills are shown in column 2. If we total up these for each variety, and from column 8 of the same table obtain the number of occasions when one or more hybrid black-grained plants were obtained in each separate progeny plot raised therefrom, we shall arrive at a figure showing the number of impure stocks which actually occurred. These are set forth in Table VII.

The results expressed in this manner are somewhat disquieting inasmuch as that fourteen out of seventy-three progenies

TABLE VII.

Showing the number of head-row progenies in the "alternate-drill" series which were impure on account of natural crossing.

Variety.	*Number of separate head-rows or 5-foot row progenies grown.*	*Number of progenies in which one or more hybrid black-grained plants were observed*
Early Ripe ...	8	2
Garton's Early ...	9	6
Red Algerian ...	13	1
Victory ...	15	4
Scotch Potato ...	28	1
Total ...	73	14

raised on a head-row or 5-foot drill basis became impure in the very first season in which they were laid down. It is true the percentage impurity of the individual stocks may be very low, but the fact remains that only fifty-nine of the seventy-three stocks can be described as being 100 per cent. pure.

If we include in our observation those varieties which showed no out-crossing, the figures obtained are fourteen impure in a total of 152 progeny plots. The proportion is much reduced, but it nevertheless means that in a miscellaneous collection of head-row stocks the chances are that 10 per cent. on the average would show some measure of impurity as a result of cross-pollination. Where the out-crossing is with a variety possessing a distinctly dominant grain colour or other distinguishing dominant feature the out-crosses if immediately rogued would not be detrimental to the genetical purity of the stock, except in so far as pollen from such plants might have led to further contamination within the stock. Where identification is impossible through out-crossing with strains of similar appearance but different genetical breeding the certainty of attaining absolute purity of the stock becomes a difficult matter. In such cases steps would have to be taken to raise stocks in plots spaced at sufficient distances apart to ensure complete freedom from any possibility of cross-pollination.

Conclusions and Summary.

Of eleven white-grained varieties studied in the seasons 1925-1929, naturally crossed black-grained plants were obtained in six varieties, while no crossing occurred in the remaining five varieties. In connection with the latter it was not entirely clear whether the absence of natural crossing was in all cases due to inherent immunity to natural cross pollination or to a restricted pollen dispersion (or some such cause) in point of time or quantity on the part of the particular black-grained varieties with which they were paired.

The lowest percentage, 0.008, of hybrid black-grained plants was exhibited by the variety Scotch Potato (*A. sativa*); the highest, 0.88, by Early Ripe (*A. sterilis culta*).

Members showing no black-grained hybrids were *A. brevis*, *A. nuda*, *A. sterilis culta*, var. Red Rustproof, and the *A. sativa* varieties Yielder and Record. Those susceptible to natural crossing were Early Ripe and Red Algerian (*A. sterilis culta*), and Garton's Early, Victory, Kösthavre and Scotch Potato (*A. sativa*).

Altogether forty-three hybrid black-grained plants were found in a total of 115,920 plants examined. This represents a percentage of 0.037. Excluding varieties showing no natural crossing the percentage figure rises to 0.058.

On the basis of the absolute degree of natural crossing taking place as distinct from the number of hybrid black-grained plants observed, these figures, as indicated in the discussion, should be doubled, and they would then become 0.074 and 0.116 respectively. These average figures are nevertheless appreciably lower than any hitherto published.

Viewed from the standpoint of the influence of natural crossing upon the production of pure stocks on a head-row or 5-foot drill basis at spacings of one foot apart, the investigations show that fourteen stocks out of seventy-three among varieties showing some degree of crossing, were observed to be impure. Taking the results as a whole, that is including those varieties which show none as well as those which show some natural crossing, 10 per cent. of all stocks growing in the " alternate-drill " series were found to contain some degree of impurity arising from crossing. Regarded from this angle natural crossing in oats occurs with a sufficient frequency in certain varieties to cause serious interference in the production of pure stocks of seed initiated on a head-to-row basis.

Acknowledgments.

The writer is indebted to Professor R. G. Stapledon, C.B.E., M.A., for his helpful interest in the work; to Mrs. E. E. Evans, B.Sc. (*née* Miss G. Lyon Jones), for assistance in 1930 and 1931 in the collection of experimental data; to Mr. Iorwerth Jones, B.Sc., for the records relating to meteorological conditions, and to Miss Rhoda Jones, B.A., for assistance with Scandinavian literature and with publication.

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MANURING OF RED CLOVER FOR SEED PRODUCTION.

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No information appears to be available on the manuring of red clover for seed production. An experiment was therefore carried out in the summer of 1932, in co-operation with Imperial Chemical Industries, Ltd., to gain some information on this subject, which is an important one in Montgomeryshire. Two farms were chosen where seed clover has been grown annually for many years, viz., New House, Forden (Mr. J. Cadwallader), and Rhiston, Churchstoke (Mr. W. Hotchkiss). The experiment, being one of a purely preliminary character, was as simple as possible, and consisted of two manurial treatments and a control.

At both centres 9 plots of one-fortieth acre were measured out in the form of a Latin square (3x3). The dressings were :—

A. Complete fertiliser (containing nitrogen, phosphate and potash).

B. Phosphate and potash .

C. No fertiliser.

The rate of application of the various ingredients was :— N : 16.8 lb. per acre; P_2O_5 : 58.24 lb. per acre; and K_2O : 16.8 lb. per acre. The amount of phosphoric acid and potash was the same in treatments A and B, but A contained in addition nitrogen equal to rather less than 1 cwt. per acre of sulphate of ammonia.

Each treatment was replicated three times at each centre, the manures being applied at the close of the grazing season, immediately after the fields were laid up for the seed crop in early June.

At harvest time the produce of all three A plots was put together in one lot. The produce of the B and C plots were similarly dealt with.

The previous cropping and manurial history of the fields on which the experiments were carried out are shown below :—

Rhiston.

1931. Oats; no manure.
1930. Roots; 12 tons yard manure per acre; 8 cwt. basic slag per acre.
1929. Wheat; light dressing yard manure.
1928. Oats; no manure.

New House.

1931. Seed clover; no manure.
1930. Barley; no manure.
1929. Oats and barley mixed; no manure.
1928. Oats; 3-4 cwt. per acre superphosphate.

It will be seen that the crop at Rhiston was in its first year, while that at New House was in its second year.

Rainfall during the Experimental Season.

The rainfall as recorded at Montgomery (about 8 miles from both centres) by Dr. R. E. G. Phillips is as follows :—

May.	*June.*	*July.*	*Aug.*	*Sept.*
2.68 inches.	4.25 inches.	0.70 of an inch.	5.41 inches.	1.64 inches.

General.

The rainfall during the season is on the whole a little below the average. The weather was exceptionally hot during part of August, which naturally hastened the ripening and encouraged the yield of seed. Unfortunately the weather broke about the middle of September : there was considerable rainfall for fully a fortnight, which caused the crop to be badly beaten down at Rhiston and much of the seed shed. But for this rain the crop at Rhiston would have been cut fully a week earlier than it actually was, another factor which led to a reduction in the yield. At New House, where the crop was in its second year, a seed crop having been taken the previous season, the plant was not more than half the length of that at Rhiston, so that it suffered less from the wet weather.

Condition of the Crops.

At Rhiston the crop was tall, thick, and uniform, but at New House it was much shorter as well as less uniform. The only observable effect of the manures was that the A plots receiving a complete dressing, looked greener and fresher in the early part of the season and carried a somewhat bulkier crop at the close. The crop at both centres was cut in the latter part of September and carried in good condition. Threshing took place in December at Rhiston, and in January at New House.

The weights given are the total yields from all the plots having the same manurial treatment at each centre :—

	New House.		*Rhiston.*	
Plots.	*Weight of seed.*	*Germination.*	*Weight of seed.*	*Germination*
A.	28½ lb.	77 per cent.	34 lb.	72 per cent.
B.	19 lb.	71 per cent.	27 lb.	69 per cent.
C.	22 lb.	72 per cent.	28 lb.	74 per cent.

Five pounds of the crop receiving each manurial treatment at Rhiston were sent to Aberystwyth College for examination by Capt. R. D. Williams, of the Welsh Plant Breeding Station, who very kindly supplies the following report :—

The following particulars were obtained by taking two samples of 500 complete heads at random from each treatment. After the florets had been stripped and weighed, these samples were reduced to one-tenth their original bulk. The florets in the reduced samples were then counted, and the seeds rubbed out by hand, weighed, separated according to quality into good, fair, and poor seeds and finally counted.

Lots ...	*A.*		*B.*		*C.*	
	Per 1,000 heads.	*Per 1 head.*	*Per 1,000 heads.*	*Per 1 head.*	*Per 1,000 heads.*	*Per 1 head.*
No. of florets ...	92,870	92.8	87,580	87.5	80,400	80.4
Weight (gm.) of total seeds ...	74.15	--	63.79	—	60.74	—
No. of seeds :						
Good	42,790	42.8	35,280	35.3	32,410	32.4
Fair	5,080	5.1	4,540	4.5	4,090	5.1
Poor	2,720	2.7	3,150	3.2	2,780	2.8
Total	50,590	50.6	42,970	43.0	39,280	39.3
No. of good seeds per 100 florets ...	46.1	--	40.8	-	40.3	--

These data are exceedingly interesting and bear out the yield results to a remarkable degree. They indicate that N combined with P and K had a two-fold effect namely (1) it increased the number of florets per head, and (2) it increased the number of seeds per given number of florets.

It is unwise to dogmatise on the results of one experiment, but the application of nitrogen for seed clover production, in

spite of a widely held opinion to the contrary, has been justified by the results in this particular year, since the heaviest yield at both centres was given by the plot to which this fertiliser had been applied. It is probable that the falling off in yield on Plot B at New House was due to the irregularity of the plant.

It is hoped to carry out a series of experiments on similar lines in the future. Thanks are accorded to Capt. R. D. Williams, of the Welsh Plant Breeding Station; Mr. Manson, of Imperial Chemical Industries, Ltd., and Messrs. Cadwallader and Hotchkiss for their help in carrying out the experiment.

MANURING RED CLOVER FOR SEED.

By Gwilym Evans, B.Sc.,
Welsh Plant Breeding Station, Aberystwyth.

Phosphates are generally used, and recommended (2) to increase the yield of red clover seed in Britain. On the Continent the phosphates are supplemented with applications of potash (3, 4). Both these mineral fertilisers appear to be valued in New Zealand for their influence on the production of white clover seed (1).

A preliminary experiment was designed last year (1932) in order to investigate the influence of fertilisers on the seed yield of red clover.

Material and Methods.

The investigation reported in this paper was carried out on single plants in ten-inch pots. For each treatment, five single-plant replications were made, giving a total of twenty pots. Since it was realised that even though the plants used were full sisters obtained by inter-crossing two plants, there might yet exist certain inherent differences in seed-producing capacity from plant to plant, cuttings were taken from the original plants selected for the work. The number of cuttings rooted was considerably in excess of those actually used, and it was therefore possible to select within each group of clones derived from cuttings of the same plant those which matched each other in size and vigour. Thus for each replication, clones of a single plant matched up to give apparently uniform vigour were subjected to each treatment. The use of five different original plants in the five replications will therefore allow for

possible variations in the response of these plants to the various treatments and will give a mean which, although not absolute, is probably more nearly comparable with the results obtained under field conditions than if all the clones used were derived from cuttings of a single individual plant. Moreover, the use of a *single* original plant for seed production comparisons is impossible owing to self-sterility. At the same time, the use of cuttings ensures that in each replication actually the same individual plant is subjected to each treatment so that the possibility of a difference from one individual plant to another in their response to different treatments is eliminated.

The lay out of the plants under each treatment is shown in the following table.

TABLE I.

Showing lay-out of the experiment.

Replicates.	*Control.*	*K*	*PK*	*PKCa*
1	a1	a2	a3	a4
2	b1	b2	b3	b4
3	c1	c2	c3	c4
4	e1	e2	e3	e4
5	f1	f2	f3	f4

The various letters indicate the original plants and the numerals indicate the clones from each of such plants.

The soil used in the pots was an average medium loam which was sterilized before potting, for the purpose of destroying the weed seeds.

The cuttings were potted in the previous November, and they were kept in a cool glass house during the winter. The manures were applied at the end of March, when the pots were removed to the open. The scheme of manuring was as follows :—

(*a*) No manure.

(*b*) K_2O (sulphate of potash) ... ... 171.4 lb. per acre.

(c) K_2O (sulphate of potash) ... ... 171.4 ,,
P_2O_5 (superphosphate) ... ... 92.1 ,,

(*d*) K_2O (sulphate of potash) ... ... 171.4 ,,
P_2O_5 (superphosphate) ... ... 92.1 ,,
Burnt lime ... ... 30 cwt.

Results.

All the clover crops kept for seed on the farm during 1932 showed a definite tendency to short growth and consequently stood up well at harvest time. This tendency was accentuated in this pot experiment ; none of the plants grew more than 18 inches in height.

The outstanding series, as judged by inspection during the summer months, was that which had been dressed with potash and phosphates only. All the plants under this treatment appeared to be more robust, had a greater number of stems and flowers than the others.

Each plant was harvested separately, as soon as it ripened, and the harvesting dates ranged from September 7th to 17th.

TABLE II.

Showing for each treatment of red clover—(a) Total number of flowering stems; (b) Total number of heads; (c) Number of florets per head; (d) Number of seeds per head; (e) Total weight of seed; (f) Weight per 1,000 seed; (g) Relative number of weights with "no manure" at 100.

	No manure.	*Potash.*	*Potash + phosphate.*	*Potash + phosphate + lime.*
Flowering stems ...	155	195	224	206
Relative numbers, no manure at 100 ...	100	126	144	133
Heads ...	406	447	515	398
Relative numbers, no manure at 100 ...	100	110	127	98
Florets per head, average of 50 ...	50	55	64	72
Relative numbers, no manure at 100 ...	100	110	128	144
Seeds per head, average of 50 ...	48	66	60	83
Relative numbers, no manure at 100 ...	100	137	125	175
Total weight of seeds in grammes. ...	8.68	17.40	21.56	18.67
Relative weights, no manure at 100 ...	100	200	248	215
Weight per 1,000 seeds ...	1.156	1.262	1.320	1.228
Relative weights, no manure at 100 ...	100	109	114	106

On the average the plants in the PK pots were four days later in ripening than the plants in the control pots, there being no

obvious differences in the maturation of the plants in the other series compared with control.

Data relative to all the plants harvested are presented in Table II : the figures indicate the influence of fertilisers on the production of red clover seed under the conditions of the experiment.

Number of Flowering Stems.

Each manurial treatment has stimulated stem production, and the number of flowering stems produced appears to have some correlation with the total yield of seed. Lime seems to have a slightly depressing effect on the number of stems produced, when the result from the PK Ca treatment is compared with that from PK. Potash has effected a definite increase in the number of stems, and with the addition of phosphates a further increase has been effected.

Number of Flower Heads.

Lime appears to have a distinctly depressing effect on flower-head production, while a more prolific production of heads has been induced by potash with phosphates. The application of phosphates with potash has increased the number of heads considerably more than that of potash alone.

Florets per Head.

Each manurial treatment has had the effect of producing more florets per head, and in this instance the addition of each fertilizer has had a cumulative effect on the heads. Although lime has brought down the total number of heads to the level of those from the control plants, yet the heads produced have derived considerable benefit by its application.

Seeds per Head.

Seed production per head has been more influenced by the fertilizers than the total number of florets per head. Here again the addition of lime has been advantageous to the extent of 40 per cent. more than the potash with phosphates.

Total Yield of Seed.

The results under this heading are even more important from the practical point of view than those already discussed. It will be observed that potash had the effect of doubling the yield of seed, and in conjunction with phosphate it has induced the production of nearly two and a half times the weight of seed harvested from the no-manure pots. The application of

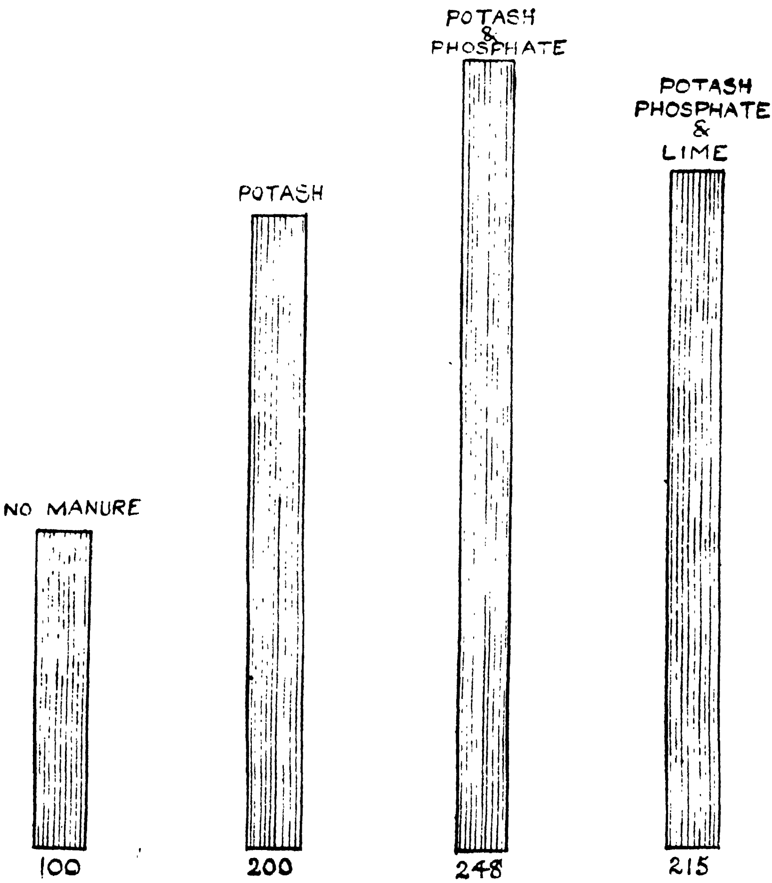
lime with the mineral manures has resulted in reducing the beneficial effect of potash and phosphate on the yield of seed.

Weight per 1,000 Seed.

Each of the dressings shows a tendency to increase the weight per thousand seeds. This is a distinct gain when it is considered that the size of seed of any given variety correlates with field establishment. It is very satisfactory to notice that both the greatest yield of seed and the best quality seed have been produced by the application of a dressing consisting of potash and phosphate.

FIGURE 1.

Relative yields of red clover seed. No manure at 100.



The Effect of Nitrogen on Seed Production.

A number of plants similar to the ones used for the above experiment were grown in pots and used to study the effect of

nitrogen on seed production in red clover. Five plants were dressed with nitro-chalk at the rate of 45 lb. of nitrogen per acre, and five corresponding plants received no fertilizer. The dressing was applied at the end of May.

The results shown in Table III were not included in Table II, since the conditions under which the plants were grown were not strictly comparable.

TABLE III.

Showing the effect of nitrogen on (a) the number of flowering stems; (b) the number of heads; (c) the total weight of seeds, and (d) the weight per 1,000 seeds of red clover.

	No manure.	*Nitrogen.*
Total number of flowering stems ...	154	199
Relative numbers, no manure = 100	100	129
Total number of heads ...	346	377
Relative numbers, no manure = 100	100	109
Total weight of seed in grammes ...	18.23	17.4
Relative weights, no manure = 100 ...	100	95
Weight per 1,000 seeds ...	1.45	1.38
Relative weights, no manure = 100 ...	100	95

The plants in this section were harvested and threshed by hand, as in the previous series. Little difference was observed in the time of ripening, or in the tendency to lodge, the growth being relatively short for a late-flowering strain of red clover.

The figures shown in Table III do not indicate that nitrogen is of value for stimulating seed production in red clover. The fertilizer has increased the number of flowering stems, but without a corresponding increase in the yield or quality of seed it fails to achieve the purpose for which it was intended. One of the main difficulties with which the grower of late-flowering red clover seed has to contend in the west is the lodging of the crops, and it is not likely that nitrogen will correct this.

General.

It must be emphasised that the results recorded here are not derived from crops grown under ordinary field conditions, and it is only legitimate to draw broad inferences.

The action of potash in stimulating seed production requires serious consideration in view of the fact that comparatively little use is made of this fertilizer as a manure for red clover seed

production in this country, and it must be pointed out that the dressing applied in this experiment was much heavier than is ordinarily applied to grassland.

There is no necessity for urging the claims of phosphates for a place in the manuring of red clover for seed as the growers are already aware of their importance.

Although lime in this instance has not proved of value, it does not follow that under different conditions it would not be of advantage as, for example, when thoroughly incorporated with the soil at the time of the preparation of the seed bed.

Nitrogen when applied alone as a dressing for red clover seed production has not justified its use even under conditions which were apparently favourable to its action.

Summary.

(1) A heavy dressing of potash has doubled the yield of red clover seed and increased the number of flowering stems, the number of heads, number of florets per head, the number of seeds per head and the weight per thousand seeds.

(2) The addition of a good dressing of superphosphate to the potash dressing has caused a further increase in weight of seed, number of heads, number of florets per head, number of flowering stems and the weight per thousand seeds.

(3) Lime when added to a dressing of potash with phosphates has reduced the effect of the mineral manures on the number of flowering stems, the number of heads and the weight per thousand seeds. On the other hand, it has caused an increase in the size of heads and in the number of seeds produced per head.

(4) Nitrogen has failed to produce an improvement in the quantity and quality of seed, but this element has increased the number of flowering stems and the number of heads.

Sincere thanks are due to Mr. R. D. Williams, M.Sc., who has taken much interest in this work, and offered many helpful suggestions.

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THE INFLUENCE OF ITALIAN RYE-GRASS ON BARLEY.

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The results recorded in this paper were derived from an experiment designed for a wholly different purpose and which will cover a period of years.

A series of seeds mixtures were laid down on May 6, 1932, using Standwell barley as a nurse crop. The nurse crop was sown thinly, at the rate of 120 lb. per acre in order to secure a good establishment of the herbage seeds, while aiming at the same time at securing a reasonable crop of corn.

Table I shows the two seeds mixtures (in lb. per acre) which are relevant to this paper.

TABLE I.

	Mixture B.	*Mixture C.*
Italian rye-grass ...	34	Nil.
Smooth-stalked meadow grass	24	24
Wild white clover ...	8	8

It will be observed that the only difference in the two mixtures is that Italian rye-grass has been omitted from Mixture C. The plots were replicated four times.

The experiment was laid down on a light loam soil which had been fallowed in the previous year. No fertilizers were applied at the time of seeding.

Results.

Very striking differences in the degree of ripeness shown by the barley on the various plots were observed towards the end of August. The cover crop in every plot on which mixture B, including Italian rye-grass, had been sown was at least a week earlier in ripening than the crops on the plots from which the rye-grass had been excluded. The lines of demarcation were perfectly defined between the plots which had been sown with the different seeds mixtures.

The barley was harvested during the first fortnight in September, and afterwards carried carefully indoors in canvas wrappers, and the yields from the plots ascertained four months after threshing in order that any differences in the moisture

content of the grain from each plot might be reduced to a minimum. Tests which were made by means of the Davies Moisture Meter (8) at the time of weighing showed that the moisture content of the barley from all the plots varied so very slightly that such differences could have no bearing on the weights obtained.

Table II shows the yields of barley on the plots (Series B) where Italian rye-grass had been sown and on the plots (Series C) where it had been omitted from the mixture.

TABLE II.

Replicates.	*With Italian rye-grass.*		*Replicates.*	*Without Italian rye-grass*	
	Barley grain per acre.	*Weight per 1,000 grains in grams.*		*Barley grain per acre.*	*Weight per 1,000 grains in grams.*
	Cwt. lb.			Cwt. lb.	
B1	12 69	53.75	C1	19 39	54.89
B2	11 66	53.03	C2	18 109	53.89
B3	11 39	53.02	C3	19 19	54.89
B4	14 66	54.68	C4	20 62	55.13
Average ...	12 60			19 57	
Relative ...	100			155	

The data presented in this table indicate significant differences in the yield of barley grain in the two series. The yield has increased by over 50 per cent. on the average in Series C as compared with Series B. This increase can only be due to the removal of the competitive effects of Italian rye-grass, for plots were so arranged that the effect of soil differences can be neglected.

The influence of the smooth-stalked meadow grass and the wild white clover can also be dismissed in considering the yields of barley, for although they had established well, their growth at harvest time was comparatively small.

When the yields from the replicates of the same series in separate blocks are considered, it will be noticed that the variation is much less than when corresponding replicates in the two series are compared. On the whole the difference in yield in corresponding replicates is greatest where the yield is least.

The weights per 1,000 grains of barley derived from the various plots show very slight variation, but there appears a tendency within each series for the weight per 1,000 grains to be correlated with yield.

Two arguments may be put forward to explain the difference in the yield of barley in the two series. Firstly,

the strong competitive effect of Italian rye-grass with barley for soil nutrients. Chippindale (1) has shown that Italian rye-grass exercises a profound influence in this respect on certain grasses. Davies (2) has reported the depressing effect of Italian rye-grass on red and white clovers, and also on other grasses, when the rye-grass is not grazed down in winter and spring. It is, therefore, reasonable to believe that a similar influence operates here. Secondly, it is suggested that the rye-grass competes with the barley for soil moisture, and the dry weather experienced during August lends support to this view, particularly when it is remembered that the soil was of a light texture. The question of soil moisture is also related indirectly to the quantity of nutrients available in the soil.

Rainfall records for August, 1932, at Frongoch show a particularly low figure for that month; 1.16 inches as compared with an average of 4.92 inches for the previous seven years. There was thus less than one-quarter of the average precipitation for the years immediately preceding.

These results suggest points of practical importance in view of the widespread interest in establishing permanent grassland by seeding. It is recognised that indigenous grasses on the whole do not develop to their maximum during the first harvest year, and thus do not compare so favourably in the early stages as the quick-growing, short-lived commercial types. Where then barley is considered a remunerative crop, and where it is desirable to have first-class permanent pasture established at the same time, there is some reason for believing that these two objects can be achieved simultaneously by excluding early growing grasses from the seeds mixture, and choosing indigenous types. The slightly reduced spring keep and the first year hay crop found by excluding the early types of grasses, would be compensated for by the increased barley crop, and the persistency of indigenous strains of grasses.

The short growth of the indigenous grasses in the nurse crop would be a definite advantage in conditioning the barley crop on the field.

If on the other hand spring grazing is the primary consideration, and at the same time it is desirable to have barley ripening early, then Italian rye-grass has much in its favour.

Thanks are due to Mr. Ll. Iorwerth Jones, B.Sc., for supplying the rainfall data.

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DEFICIENCY OF THE CLOVER NODULE ORGANISM ON SOME WELSH SOILS.

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Introduction.

It is not unusual in America and in Australasia to meet with a deficiency of the clover nodule organism. In view of the widespread occurrence of wild white clover throughout Great Britain in all our pastures and meadows it is interesting to find there are likely to be large areas of high grassland in Wales which are not only deficient in wild white clover, but deficient in the clover nodule organism as well. Feilitzen (1899) quotes results showing this to be the case on high moorland in Sweden—" Högmosse."

The significance of this from the point of view of the improvement of Welsh hill pastures may well be imagined.

The first indication of a deficiency of the organism came from Breconshire, from the estate of Mr. S. M. Bligh, of Cilmery Park, Builth Wells. The Goytre Land is a 10-acre field on a steep hillside standing at about 1,000 feet above sea-level, which immediately adjoins the open hill with its sheep grazing rights. It consisted originally of bent (*Agrostis* spp.), and fescue (*Festuca* spp.), with a large amount of bracken (*Pteridium aquilinum* Kuhn.) and some gorse (*Ulex europaeus* L.), the other leguminous plants present being *Lotus corniculatus* L. and *Lathyrus* spp. On the rare occasions when natural clover occurred it was close to a gate or stile.

Ploughed in the winter 1930-1, the Goytre Land was given North African Phosphate at 6¼ cwt. per acre in the spring and sown down in May, 1931, with mixtures containing pedigree grasses from the Welsh Plant Breeding Station, together with wild white and red clovers.

In July and August the poor growth and colour of the grass and clover seedlings was attributed to infertility and the cutting off, by unrotted turf, of soil moisture. The clover seedlings were puny and yellow, with relatively long root systems. The root systems then, and still in September, were entirely deficient in nodules. For comparison, clover plants sown on a ley a few fields down the slope on land in rotation were examined. Not only were the plants considerably larger, but they were well nodulated. Seedlings of the other *Leguminosae* present, on the Goytre Land, of approximately the same age, developed healthy nodules, but as is well known the clovers are infected by different strains of *Bacillus radicicola* (Thornton, 1931).[1]

In an endeavour to help the plants to overwinter, the bulk of the area was given ammonium sulphate, nitro-chalk, ammonium phosphate, superphosphate and kainit in various amounts. At the same time a sack of soil, moist, and freshly dug from an old ley nearby, which was very rich in white clover, was applied to 1/10th acre. Two lime plots of 1/10th and 1/20th acre at 2 ton and 10 cwt. respectively had already been put down on the surface in June.

A cursory comparison of the soil-inoculated plot with the bulk of the area in March, 1932, revealed sturdy, well-nodulated plants, contrasting favourably with those plants surviving the winter elsewhere. Moreover, these latter plants were only occasionally nodulated. A theory of nodule organism deficiency would, moreover, account for a certain tardiness and patchiness in wild white clover establishment on other land improved by Mr. Bligh.

Further inoculation experiments, both with soil and inoculated seed, were conducted in 1932. One area, the Coryn Land, close to and on similar soil to the Goytre Land, had been ploughed in 1932 and sown down that spring. The other area is on a totally different soil—a dry peat, carrying pasture of the *Nardus-Molinia* type. This was ploughed in the autumn of 1931 by Captain Bennett Evans on his land at over 1,000 feet on the Plynlimon foothills.

Except for survival figures based on clover establishment counts from the Goytre Land in 1931, all the following data were obtained in 1932.

Goytre Land.

An analysis was made of the greater part of the area to determine the establishment of white and red clover under the

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[1] Thornton summarises the work of numerous investigators in this field.

different treatments. This involved a minimum of fifty readings per half-acre by means of the 6-inch mesh, according to the technique adopted at the Welsh Plant Breeding Station. On critical plots, such as the soil inoculated, limed and control areas close by, as many as 100 readings per 1/10th acre were made.

Plots were analysed by plant and tiller counts as well as by estimating the percentage area covered, and a record was kept of all " puny " plants according to an arbitrary distinction. A " puny plant " consisted of one or two small yellowish leaves and a fragment of root. Such plants are probably comparable to the " latent seedlings " of Chippindale (1931; 1932). The standard was decidedly high and might possibly with advantage have been lowered so as to include many more plants. Owing to the rather poor condition of most of the plants the " three inch " method of Jenkin (1919) was discarded, every shoot being regarded as a unit. In white clover an almost constant relationship was found between the estimated percentage area covered and the number of shoots. For red clover, numbers of plants are given, as the area covered was in any case very small. Care was taken to distinguish plants from original seedlings, as distinct from their vegetative propagants. This was simple except on the limed and inoculated plots where growth was more vigorous.

It was found that the " empty mesh frequency " (*i.e.*, the number of times the mesh was thrown without encountering clover) was very closely in inverse ratio mathematically to the percentage area covered. Hence one replicate of the nitrogen plots and all the ammonium phosphate plots, amounting to about half the main area, were rapidly surveyed for white clover by counting the empty mesh frequency, the percentage area being calculated in order to give an approximate figure for comparison.

For the sake of convenience, since the manurial plots showed no significant differences when compared one with another or with the unmanured control plots, the data for the bulk of the area, about eight acres, have been grouped. Similarly the data for the two lime plots were put together.

The figures set out in Table I show that over the greater portion of the Goytre Land initial establishment of clover has failed, and that there has been a high mortality of wild white and red clover seedlings during the winter 1931-2.

Establishment is greatest and mortality least on the plot inoculated with wild white soil. The limed plots are intermediate between this and the immediately adjacent uninoculated area. The need for inoculation as well as lime on acid soils is stressed by many American and Colonial workers, for example, Albrecht

and Poirot (1930), Wilson and Leland (1929). It is likely that, with lime and inoculant together, establishment would have been still better.

Moreover, on the limed and inoculated plots the plants are healthier as indicated by the negligible percentage of "puny

TABLE I.

Clover establishment on the Goytre land.

Area.	*Per cent. area covered.*	White Clover. *Per cent. seedling survival.*	White Clover. *Per cent. "Puny" plants.*	Red Clover. *Plants per 100 readings.*	Red Clover. *Per cent. seedling survival.*	Red Clover. *Per cent. "Puny" plants.*
Soil inoculated ...	20	58	0	42	25	2
Limed ...	12.5	40	0.5	24	18	0
Uninoculated—adjacent ...	4	19	12	13	10	50
Main area—detailed analysis ...	4	16	12.5 (17,424 per acre)	18	14	80 (9,006 per acre).
Main area—rapid analysis ...	4	—	—	—	—	—

plants." On the main area, these amount to a significant figure, particularly in view of the severity of the definition puny; 17,424 per acre amounts to about 8½ per square yard. Whether an application of soil in September, 1932, came in time to save these remains to be seen.

It is clear that inoculation of the whole area with suitable soil in the year of sowing would have given successful establishment of wild white clover.

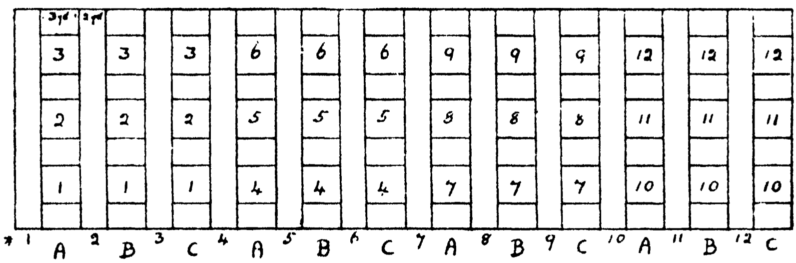
Coryn Land.

This land, about 6½ acres, is very similar to the Goytre Land, and was similarly sown with rock phosphate in the spring previous to seeding down on June 8, 1932.

The lowest acre was reserved for inoculation experiments, and was given a thin sowing, relatively to the main area, of two different grass mixtures. On each of these half-acre plots two replicates of plots were laid out according to the scheme set out hereunder, so that there were four replicates in all. All plots were measured by pacing.

FIGURE 1.

Plan of one Replicate.



KEY TO TREATMENTS.

A = Seed inoculation.†
B = Soil inoculation.
C = Control—no inoculation.

CaO = Lime (in tons) per acre.
P = Slag (in cwts.) per acre.
K = Kainit (in cwts.) per acre.
N = Nitro chalk (in cwts.) per acre.

CLOVER MANURIAL PLOT.

1. CaO at 1.
2. CaO at 2.
3. P at 2½.
4. P at 5.
5. P at 2½ + K at 1.
6. P at 5 + K at 2.
7. CaO at 1 + P at 2½ + K at 1.
8. CaO at 2 + P at 5 + K at 2.
9. CaO at 1 + P at 2½ + K at 1 + N at 1.
11. CaO at 2 + P at 10 + K at 4 + N at 4.
10. CaO at 2 + P at 5 + K at 2 + N at 2.
12. Control—no manure.

Wild white clover plots at 10 lb. to the acre, each nine square yards, and separated from each other by two yards, were sown out by hand on June 16 and covered rather sparingly by means of a hay rake.

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* 1, 2, 3, etc., represent non-clover strips manured according to the above scheme.

† The cultures used were kindly supplied by Dr. Thornton, Rothamsted, the strain having originally been sent to him from the Wisconsin Experiment Station.

The seed used for " A " series had been inoculated two days before.

Manures were applied between July 7 and 20 on top of the young seedlings, then at the first leaf stage. In most cases, owing to the dry weather, the manures remained on the surface for some days before being washed in.

Lime, first slaked, and applied cold, was in excellent condition for spreading.

Soil, from Orchard Field (where wild white clover was present in abundance), Frongoch, Aberystwyth, was applied on July 15, at nearly 2 tons per acre.

Sheep were excluded until after the nodule counts were made.

Nodule counts, made between August 23 and 31 involved digging twenty-five plants from each plot and removing the soil from the roots by very careful washing. Great care had to be exercised to avoid any loss of nodules. When nodules were present they could usually be seen by reversing the clod under water, before removing all the soil. In no case was a plant seen thus to be nodulated, found nodule-less after washing. Rarely an unattached nodule was found, but it always came from " B " series. Counting was done on the bright surface of a tin lid.

Arbitrarily the following distinctions were made according to eye measurement :—

(1) Nodules on the first inch of root system = R.
(2) Nodules below the first inch = Rt.
(3) Big nodules—measured over 2 mm. in any one plane.
Medium nodules—measured between 1 and 2 mm.
Small nodules—measured less than 1 mm.

In addition to the small plots, one acre of a mixture on the main area received an additional 5 lb. of inoculated white clover seed.

On September 9, subsequently to a " nodulation survey " of the main area, two acres of the main area immediately adjoining the small plots received wild white soil at roughly 15, 8, and 4 cwt. per acre, with two control plots. These were all analysed for nodulation early in November.

Figure 2 indicates the relative positions of the various plots.

Subsequently to the sowing of the seeds, a marked difference was observed between two parts of the field, the left, or easterly, side being conspicuous for a more vigorous growth of *Holcus mollis* L. and bracken, but less vigorous growth of the sown rape. The last replicate of the small plots, and plots B 10, 11, 12, and

C 10, 11, 12, of the adjoining area were thus under some different soil condition from the remainder. Moreover, the boundary between the two regions was a straight line parallel to the western hedge (see Figure 2).

This definitely indicated a lasting effect from some pre-treatment not known to the present occupier, although the land had

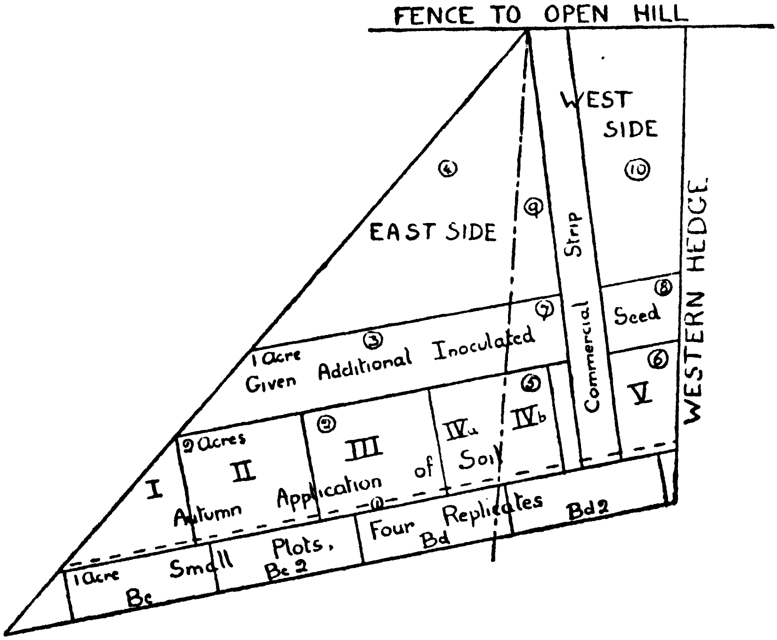

FIGURE 2. Plan of Coryn Land.

I. Soil at 15 cwts. per acre.
II. Control—no soil.
III. Soil at 8 cwts. per acre.
IV. Control—no soil.
V. Soil at 4 cwts. per acre.
Bc, Bc2, Bd, Bd2, are symbols for the replicates.
1, 2, 3, etc. = areas separately analysed in the nodulation survey.
—— - —— - —— - Boundary between eastern and western (probably pre-limed) sides.

not been ploughed for sixty years. That this pre-treatment consisted in liming is borne out by the finding of occasional limestone fragments on this side by the ploughman, as well as by the contrast in the weed herbage. Subsequent results on the small plots and from the " nodulation survey " of the whole Coryn Land seem to confirm this.

Results on Coryn Land.

The results from the small plots show that soil inoculation has produced outstanding results as regards nodulation—see Tables II and III.

TABLE II.

Coryn Land, Small Plots. Nodule Totals from Four Replicates.

Series.	*Manurial Plots.* 1	2	3	4	5	6	7	8	9	10	11	12
A Culture ...	3	4	13	15	2	25	43	20	17	9	9	0
B Soil ...	158	183	387	385	435	403	346	313	316	265	374	55
C Control ...	7	0	12	12	4	45	18	8	21	8	13	0
Total ...	168	187	412	412	441	473	407	341	354	282	396	55
Relative Value ...	35.5	39.5	87.1	87.1	93.2	100	86	72.1	74.8	59.6	83.7	11.6*

100 plants examined for each treatment.
* 80 per cent. of nodules on 12 are from plots on the western side.

TABLE III.

Coryn Land Small Plots.

Series.	*Plants nodulated.*	*Total nodules B at 100.*	*Ratio R/Rt nodules.*	*Nodules per plant nodulated.*
A	6 per cent.	4.4	2.3	2.2
B	74 per cent.	100	14.1	4.1
C	5 per cent.	3.8	1.5	2.3

1,200 plants examined for each series.
R = Nodules on first inch of root system.
Rt = Nodules below first inch of root system.

There is no difference between the culture series " A " and the control untreated "C." The failure of the culture may possibly be attributed to poor covering of the seed followed by a fortnight's exposure to hot sunny weather or to the culture being more sensitive to acidity than the soil bacteria (Alway and Rost (1926)). Thornton (1931) suggests this may be due to the presence of acidity resisting strains in the applied soil.

The manurial plots (Table II) 3-11 show no very significant differences in nodulation, but the lime plots 1 and 2, as opposed to 3 and 4 treated with slag alone, and more particularly as opposed to the control plot 12, are interesting.

As would be expected, phosphate has definitely increased nodulation more than has lime alone, there being no significant

differences between the two rates of application. Since slag contains a certain amount of free lime the difference cannot certainly be attributed to phosphate only.

In the second case, it is seen that nodulation on plot 12 is less than 1/8 of that on 1 and 2. This suggests that lime is so deficient as to be definitely deficient as a plant food, especially since 80 per cent of the actual nodulation on 12 comes from plots situated on that western area already suspected of former liming. Moreover, Bd2, the replicate entirely on this (the pre-limed) area, shows a total nodulation of 159, compared to 100 and 105 on the others. See Table IV.

TABLE IV.

Coryn Land Small Plots. Comparison of Replicates.

Replicate.	*Nodules.*			
	Total.	*Comparison Bc and Bc2 at 100.*	*Average total of limed plots.*	*Totals on no manured plots.*
Bc	846	100	36	2
Bc2	849	100	36	9
Bd	890	105	40.5	25
Bd2	1,846	159	71	19

Bc = Cocksfoot areas.
Bd = Timothy areas.
900 plants examined on each replicate.

Albrecht and Davis (1929) have shown the physiological importance of calcium in legume inoculation by growing the divided root system of a soybean plant in limed and lime-deficient soil, when the difference in nodulation between the two halves was as great as when the whole plants were used. Calcium chloride produced the same effect.

The nodulation survey of the main area shows that there is a certain amount of natural nodulation on the sown clover plants, which, from being negligible at the bottom of the field increases to the top, and is greatest on the western, and probably previously limed, area. (See Figure 2 and Table V).

This natural nodulation is characteristic, the nodules being small and scattered over the whole root system, whilst on the soil inoculated plots and on plants taken from a normal ley the nodules are larger. (See Table VI). Where soil is applied, the nodules arise close to the zone of application, *i.e.*, the soil surface. (See Tables III and VI, Ratio R/Rt and nodules Big ÷ Medium).

If size is any criterion, these small nodules represent a different, if not a less effective strain of bacterium from that used in inoculation. Helz, Baldwin, Fred (1927).

TABLE V.

Nodulation Survey of Coryn Land taken August 30–September 7, previously to Autumn Soil Application.

Nos. on Plan.	*Area.*	*No. of plants analysed.*	*No. of plants nodulated.*	*Nodule relative top, West, at 100.*	*Nodules per plant nodulated.*	*Per cent. nodulation big and medium.*
1	Extreme edge of lowest two acres by small plots ...	78	1.3	0.32	2 (1 pl.)	—
2	Lowest two acres, EAST ...	68	9	3.1	3	—
3	Seed Inoc. acre, Top, EAST ...	103	*25	5.4	1.7	50
4	Uninoc. two acres, Top, EAST	50	10	5.5	4	13.7
5	Lowest two acres, WEST, on left of Commercial strip ...	64	17	4.7	2	20.8
6	Lowest two acres, WEST, on right of Commercial strip ...	67	28	19.8	5.5	2.8
7	Seed Inoc. WEST, to left of Commercial strip ...	87	57.5	19.4	2.6	32.6
8	Seed Inoc. WEST, to right of Commercial strip ...	60	66.6	37.7	4.5	9.9
9	Top two acres, WEST, to left of Commercial strip ...	43	65	45.9	5.5	10
10	Top two acres, WEST, on right of Commercial strip ...	38	89	100	9	2.3

* Half of these plants had only one small nodule.

On the eastern area, Table V, Fig. 2 (3), where a culture was used, 25 per cent. of the plants are nodulated, with 50 per cent. of larger nodules. But since half of these nodulated plants had only one small nodule each, confirmatory evidence of complete failure or some success will depend on establishment data in 1933.

TABLE VI.

Comparison between Type and Position of Nodulation in three representative areas.

	No. of plants.	*No. of plants nodulated.*	*Nodules per plant nodulated.*	*Ratio R/Rt nodules.*	*Per cent. nodules big and medium.*
Normal ley*	15	100	11.5	1.4	42.4
West, Top of Coryn	38	89	9	.8	2.8
"B" Series Small plots	1,200	74	4.1	14.1	26.7

R = Nodules on first inch of root system.

Rt = Nodules below first inch of root system.

* Land in rotation, immediately adjoining the field whence soil taken for original inoculation of the Goytre land. Nodulation was healthy and abundant. Undoubtedly many nodules were lost as the plants were so vigorous it was difficult to remove them with the hand fork which had been so efficient elsewhere.

The figures resulting from the examination of plants treated with soil in the Autumn are shown in Table VII.

The effect on nodulation is evident although not quite as great as that from an earlier application, Table IV. The evidence from control plot IV is consistent with higher natural nodulation on the western area. It is interesting to note the difference between plots IVb and V. In comparing these plots it appears that inoculation by soil has influenced both the number of plants nodulated and the size of the nodules, but has decreased the total number of nodules per plant. It is possible that this might be explained by assuming a success of the introduced possibly more effective strain in competition with the indigenous one, since Dunham and Baldwin (1931) successfully inoculated with effective strains plants already nodulated with ineffective strains.

Plynlimon.

Three plots of ½ acre each were sown in early May by Mr. M. T. Thomas, Adviser in Grassland for Wales. All three received clover cleanings at 10 lb. per acre, together with the grasses, and slag and nitro-chalk at 5 and 1 cwt. respectively.

Plot I served as a control. Plot II was sown with inoculated seed. Plot III was given wild white soil at 2 cwt. per acre.

These plots were analysed in October for nodulation but not for comparative establishment. Judging by the scarcity of the plants there had already been a high mortality.

TABLE VII.

November Analysis of Autumn Soiling.

	Plot.	*Per cent. plants nodulated.*	*Relative number of nodules I at 100.*	*Nodules per plant nodulated.*	*Per cent. Nodules big and medium.*
I	At, say, 15 cwt. per acre ...	53	100	11.7	13
II	Control—no soil ...	3.5	1.7	3 (1 plant)	—
III	At, say, 8 cwt. per acre ...	23	28.1	7.6	18
IVa	Control—no soil EAST ...	0	0	0	—
IVb	Control—no soil WEST ...	27	*93.1 (54)	*15.6 (3.9)	6
V	At, say, 4 cwt. per acre ...	50	18.8	2.3	50

Between 25 and 35 plants were taken for analysis in each case.
* One exceptional plant had 66 nodules. Excluding this plant, the figures become 54 and 3.9 respectively.

TABLE VIII.

Inoculation plants. Plynlimon.

Plot.	*Plants examined.*	*Per cent. plants nodulated.*
I. Uninoculated ...	29	24
II. Seed inoculated ...	21	62
III. Soil inoculated ...	29	100

The figures (Table VIII) speak for themselves and show striking differences despite the fact that the plots were immediately adjacent and open to infection by transference of the bacteria by

sheep. An outstanding feature of a typical noduleless plant was its large root system. It is possible that an analysis earlier than October might have shown an even greater contrast. The partial success of seed inoculation with the same strain used on Coryn Land is due possibly to moister conditions and deeper covering of the seed.

Discussion.

A deficiency of the clover nodule organism on the hill soils here considered is obviously important since they are typical of a vast area of hill grazing land which is capable of improvement.

It would probably pay, when introducing clover on such land, to apply a few sacks of wild white clover soil per acre, or the appropriate strain of the nodule organism to the seed. Even if there are a few bacteria of a local strain present, an advantage is to be obtained by supplementing them (Dunham and Baldwin (1931), Wilson and Leland (1929)). Moreover, the introduced strain may be more efficient than the local strain.

In considering the seasonal pressure of farm work it may be more convenient to apply this soil in autumn or winter even, but there is no evidence yet to tell whether this would be sufficiently effective.

A point which is of practical importance is that although calcium is likely to be a necessary factor in assisting clover establishment on these areas, it may not be essential to apply heavy dressings of lime. According to Albrecht and Poirot (1930), only limited areas of limed soil close to the clover roots are needed in order to obtain a good establishment of red clover. They succeeded, by applying 300 lb. per acre of lime drilled with 200 lb. of soil and the seed.

It is even possible that the calcium present in ordinary slag or rock phosphate, which it is necessary to apply, may be sufficient without liming at all.

Mr. Bligh has succeeded in establishing wild white clover on four acres of the Coryn Land below the present experiments, using rock phosphate only. But the clover took three years to appear in any quantity; even then it was patchy, and large areas are still deficient.

This slow establishment was undoubtedly due to the deficiency of the organism. Inoculation, with rock phosphate as the only manure, resulted in successful establishment on the Goytre Land in the first year.

Summary.

1. Evidence is presented of a deficiency of the clover nodule organism on two vastly different types of hill land in Wales.

(*a*) A bent-fescue-bracken-gorse area.

(*b*) A *Nardus-Molinia* area.

2. Inoculation with wild white clover soil has assisted the establishment, vigour, and nodulation of clover seedlings on these soils.

3. Lime assisted establishment without inoculation, but to a lesser degree.

4. In the absence of phosphate, as slag, lime was essential for successful nodulation, even when a soil inoculant was used.

5. Numbers of " puny " wild white clover plants were recorded amongst those surviving in the year after sowing, on land deficient in the clover nodule organism.

6. Inoculation is recommended when attempting to improve clover-deficient land of these types.

Acknowledgments.

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THE EFFECT OF VARYING THE PERIOD OF REST IN ROTATIONAL GRAZING.

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In recent years many farmers have increased the production of their grassland by adopting a system of high manuring in conjunction with the rotational grazing of their pastures. The advantages of rotational grazing have long been recognised (1) but during the last few years there has been a considerable amount of controversy as to the length of rest a pasture should have between each grazing. It has been shown (2 and 3) that young grass is more nutritious than older grass, but experiments (3 and 4) have shown that pastures grazed often give less total bulk than pastures rested for long periods. It is thus of importance for a farmer to decide what frequency of grazing will give him the best animal production, or, in other words, how long he can allow his pastures to grow before they deteriorate in feeding value? The same question put in another form is, how often can a pasture be grazed without seriously reducing the total bulk of herbage produced? The present experiment was designed to ascertain the degree of frequency of grazing compatible with the highest animal production.

The experiment, which was started in 1928, was conducted on Spring Field, at the Welsh Plant Breeding Station. The first and second harvest year—1928 and 1929—grazing data have already been published (5), and the present paper is chiefly concerned with the third and fourth year results, 1930 and 1931. The sward consisted of several mixtures of grasses and clovers sown in June, 1927, and the grazing was so arranged that the sheep had equal access to all the mixtures under each scheme of grazing. The whole area received a dressing of 3½ cwt. per acre of superphosphate 35 per cent. on April 21, 1930.

Nitrogenous manure in the form of nitro-chalk was applied three times in 1930 and twice in 1931, at the rate of 1½ cwt. per acre for each dressing.

The area used for the experiment consisted of 1.8 acres fenced off from the rest of the field. It was then divided into three strips, A, B, and C, each of which was further divided into five plots by means of hurdles.

Grazing management.

The three traverses were treated exactly alike, except that each plot on :—

Traverse A had 4 weeks rest between successive grazings.
Traverse B had 2 weeks rest between successive grazings.
Traverse C had 4 days rest between successive grazings.

Sheep. The sheep used for the grazing consisted mainly of yearlings. In 1930, however, young weaned lambs were placed on the plots when the sheep were re-arranged on July 12. During the next fortnight, which was rather wet and cold, nearly all the lambs were scouring and they lost in weight and condition to a marked extent,[1] so that on July 25 they were replaced by a further supply of yearling sheep. In the spring of 1931 two pairs of ewes and lambs were placed on each traverse along with three yearlings. In July, 1931, these were replaced by four pairs of ewes and lambs, together with one yearling until the end of August, when the lambs were weaned and taken off the plots. The sheep were grouped and weighed in accordance with the usual method (6) adopted at the Station.

Discussion of results. Third harvest year—1930.

Results. Table Ia shows the increase in live weight of sheep obtained during 1930, and Table Ib the number of sheep grazing days provided by each area for the same year. On comparing the two tables it is found that during the period " April 25 to May 30 " the increase in weight was similar on all areas, whereas the " four weeks' rest " pasture gave over 80 per cent. more grazing days than either of the other two. During the period May 30 to July 12 the " four weeks' rest " pasture gave a similar increase in live weight to the " four days' rest " pasture, but here again it gave over 80 per cent. more grazing days. For the same period the " two weeks' rest " pasture gave 18 per cent. less increase in weight, but 18 per cent. more grazing

[1] These lambs had previously been treated for stomach worms, but large numbers of tapeworm proglottids were passed with their faeces.

days than the " four days' rest " pasture. In the last period—July 25 to October 17—no followers were placed on any of the treatments. During this period the best gain in live weight was made by the sheep grazing on the " two-weeks rest " pasture, and the poorest by those on the " four days' rest " pasture.

TABLE I.

Showing 1930 results.

(a) Increase in live weight* of sheep expressed as lb. per acre.

Resting period of sward.	*Period of the year.* April 25 to May 30.	May 30 to July 12.	July 25 to Oct. 17.	*Total for 1930.*
4 weeks ...	151	100	138	389
2 weeks ...	150	82	158	390
2 days ...	154	102	126	382

(b) Number of grazing sheep days† per acre.

(1) *Leaders.*				
All traverses ...	373	533	940	1846
(2) *Followers.*				
4 weeks ...	120	450	—	570
2 weeks ...	—	333	—	333
2 days ...	—	207	—	207

* Live weight increase was taken on leaders only.

† The number of " leaders " is the same on all traverses, whilst the number of sheep put on plots as " followers " and the time they were left on the plots depended on the amount of food offering after the leaders had moved forward.

Taking the results for the whole year is will be seen that the difference between the increase in live weight produced by the three treatments is negligible, 8 lb. being the difference obtained between the best and the poorest. The amount of grazing provided by these pastures, however, varies considerably, that of the " two weeks' rest " pasture being 6 per cent. more, and that of the " four weeks' rest " pasture being 18 per cent. more than that of the " four days' rest " pasture.

TABLE II.

Showing 1931 results.

(a) Increase in live weight of sheep expressed as lb. per acre.

Resting period of sward.	*Period of the year.* *April 23 to May 29.*	*May 29 to July 16.*	*July 16 to Sept. 24.*	*Total.*
4 weeks ...	194	120	50	364
2 weeks ...	187	126	26	339
4 days ...	162	125	— 9	278

(b) Number of grazing sheep days.

(1) *Leaders.* All traverses ...	420	660	1,050	2,130
(2) *Followers.*				
4 weeks ...	0	0	45	45
2 weeks ...	0	0	0	0
4 days ...	0	0	0	0

Table IIa shows the live weight increase of sheep in 1931—fourth harvest year, and Table IIb the number of sheep grazing days provided by each traverse during that year. It is seen from these figures that only a few extra sheep or " followers " were used during this year, so that the total number of sheep days was similar on all traverses.

During the period April 23 to May 29 all the plots were subjected to the same grazing management. The plan followed was to give each plot two weeks' rest between the grazings, consequently each plot was grazed twice during the period under review. This procedure was adopted in order to test the value of the early growth following upon the three methods of grazing. The weights of herbage taken from the plots in previous years had already indicated that the " four weeks' rest " was most favourable to early spring growth, whilst the " four-day rest " pasture gave least spring growth. This is borne out by the figures (live weight increase) given for the early grazing period of 1931 (see Table IIa). The " four weeks' rest " pasture gave the highest increase in live weight and the " four days' rest " pasture the lowest increase.

After May 29 the original scheme of grazing was again adopted. During the following six weeks there was little difference in the live weight increase produced, but between July 16

and September 24 the differences were pronounced. The " four weeks' rest " pasture gave a fair increase in live weight, the " two weeks' rest " pasture gave about half that increase, whilst the sheep on the " four days' rest " pasture actually lost weight. Thus the total increase in live weight for the whole year varied considerably, the sheep on the " four weeks' rest " pasture giving 86 lb. more, and those on the " two weeks' rest " 61 lb. more live weight increase than those of the " four days' rest " pasture, or, in other words, the sheep on the " four days' rest " pasture produced only 76.5 per cent. of the increase in live weight produced by those on the " four weeks' rest " pasture.

On comparing the two years 1930 and 1931 it is particularly to be noted that the stocking of the plots by " leaders " was heavier in 1931 than in 1930, and whereas a large number of extra sheep grazing days were available for " followers " in 1930 there were but few such days available in 1931. Thus the " four-weeks rest " pasture gave its increased productivity as extra grazing days in 1930 and as extra live weight increase in 1931. This result was probably in large measure due to what amounted to under-stocking of the plots of " leaders " in the early part of 1930, when the growth of grass was unusually abundant as the result partly of a dressing of phosphatic manure and partly of exceptionally favourable weather conditions. These circumstances led to a very rapid growth of herbage on the " four weeks' rest " pasture during the early summer. The herbage on this pasture showed a tendency to become coarse and stemmy and was not conducive to the production of a higher increase in live weight of sheep than plots with slightly less bulk but of better quality. There was a considerable amount of herbage left after the " leaders ", which was cleared up by " followers," thus increasing the number of sheep grazing days.

As has been previously stated as a result of the heavier stocking with " leaders " in 1931, practically all the herbage was cleared, and thus the increased productivity of the " four weeks' rest " pasture is shown as live weight increase of the sheep.

Table IIIa indicates the live weight increase of the sheep on the three pastures for the four years during which the experiment was conducted. From this it is seen that the " two weeks' rest " pasture gave 95.5 per cent. and the " four days' rest " pasture gave only 83.2 per cent. of the live weight increase produced on the " four weeks' rest " pasture. This means that the " four weeks' rest " pasture produced 49 lb. more increase in live weight than the " two weeks' rest " pasture, and 186 lb. more than the " four days' rest " pasture.

Table IIIb shows the number of sheep grazing days provided by the three pastures for the four years. The figures also show that the " four weeks' rest " pasture has done better than either of the other two; the " two weeks' rest " pasture producing 91.9

TABLE IIIa.

Showing the live weight increase of sheep for the four years 1928-1931 (inclusive), expressed as lb. per acre.

Period of rest of pasture.	*1928.*	*1929.*	*1930.*	*1931.*	*Total.*	*Relative increase in weight.*
4 weeks ...	183	175	389	364	1,111	100.0
2 weeks ...	166	167	390	339	1,062	95.5
4 days ...	133	132	382	278	925	83.2

TABLE IIIb.

Showing the number of sheep grazing days per acre, carried on each of the three pastures for the four years 1928-1931 (inclusive).

Period of rest of pasture.	*1928.*	*1929.*	*1930.*	*1931.*	*Total.*	*Relative number sheep days.*
4 weeks ...	1,557	1,865	2,417	2,175	8,014	100.0
2 weeks ...	1,355	1,700	2.180	2,130	7,365	91.9
2 days ...	1,225	1,695	2,054	2,130	7,104	88.6

per cent. and the " four days' rest " pasture 88.6 per cent. of the number of sheep grazing days given by the " four weeks' rest " pasture.

Taking these two sets of data together it is evident that the " four weeks' rest " pasture has given far better results than the " four days' rest " pasture. The " two weeks' rest " pasture occupies an intermediate position; it approaches the " four weeks'

rest " pasture in regard to increase in weight, and the " four days' rest " pasture in regard to the number of sheep grazing days.

TABLE IV.

Showing the average winter and early spring growth of the pasture expressed as lb. per acre. (The figures in brackets show the relative value—that of the " four weeks' rest " pasture being placed at 100).

	Rest period of pasture.		
	4 weeks.	*2 weeks.*	*4 days.*
(*a*) Spring 1929, 1931 and 1932.			
Yield of all species ...	1,833 (100)	1,192 (89)	1,002 (75)
Yield of cocksfoot ...	415 (100)	211 (51)	94 (22)
Yield of indigenous cocksfoot ...	618 (100)	353 (57)	146 (24)
Yield of commercial cocksfoot ...	212 (100)	69 (33)	42 (20)
(*b*) Spring 1931 and 1932.			
Yield of indigenous cocksfoot ...	615 (100)	371 (60)	181 (21)
Yield of commercial cocksfoot ...	116 (100)	8.5 (7)	2.5 (2)

The effect of grazing management on winter and early spring growth.

At the commencement of grazing each year, with the exception of 1930, small areas of the pasture were cut on each plot. The herbage was collected, dried in scrim bags, weighed and analysed. The average results of the three years are shown in Table IV. From this table it is seen that the management of the pasture in any one year affects its growth in the following year. The plots which had a " four weeks' rest " between successive grazings gave on an average 148 lb. more spring growth than those which had " two weeks' rest," and 331 lb. more than those which had only " four days' rest." This corresponds to a decrease of 11 per cent. and 25 per cent. respectively.

The decrease in yield resulting from too frequent grazing is not the same for all species. The yield of cocksfoot, for instance, was reduced by 41 per cent. on the " two weeks' rest " pasture, and by 78 per cent. on the " four days' rest " pasture, as compared with its yield on the " four weeks' rest " pasture. This decrease is far more marked in cocksfoot than in the total herbage and therefore it follows that some species must react either differently or to a different degree as compared with other species. Furthermore, it is rendered apparent that even different strains of the same species—cocksfoot—react to a different degree. The

spring growth of indigenous cocksfoot was reduced by 48 per cent. on the "two weeks' rest" pasture and by 76 per cent. on the "four days' rest" pasture, whilst that of commercial cocksfoot was reduced by 67 per cent. and 80 per cent. respectively as compared with their yields on the "four weeks' rest" pasture.

Leaving out of consideration the 1929 results which were obtained after only one year's grazing, the data for commercial and indigenous cocksfoot are far more striking for the spring of 1931 and of 1932, as is shown by the figures in Table IVb. In these two years indigenous cocksfoot was reduced to 60 per cent. on the "two weeks' rest" pasture and to 21 per cent. on the "four days' rest" pasture of its yield on the "four weeks' rest" pasture, whereas commercial cocksfoot was reduced to 7 per cent. and 2 per cent. respectively of its yield on the "four weeks' rest" pasture.

The above data show that cocksfoot does not thrive on areas which are grazed very often, but that this grass does relatively well on areas receiving four weeks rest between successive grazings. The data also show that commercial cocksfoot suffers far more from frequent grazing than does the indigenous cocksfoot.

TABLE V.*

Showing the average percentage composition of the three pastures in 1930 and 1932.

	Date of analyses.		*Increase or decrease. Per cent.*
	(1) March, 1930. Per cent.	*(2) September, 1932. Per cent.*	
Perennial rye-grass ...	12.4	5.1	— 7.3
Crested dogstail ...	10.8	4.8	— 6.0
Rough-stalked meadow grass ...	14.5	2.6	—11.9
Cocksfoot ...	4.4	5.0	+ 0.6
Wild white clover ...	1.9	10.2	+ 8.3
Yorkshire fog ...	7.3	16.0	+ 8.7
Bent ...	33.3	50.0	+16.7
Other grass weeds ...	11.8	4.1	— 7.7
Miscellaneous weeds ...	3.6	2.2	— 1.4
Number of tillers per 6 in. × 6 in.	873	258	

* It is probable that some of the differences shown in the above table are partly due to the analyses having been made at different times of the year.

The effect of grazing management on the botanical composition of the pasture.

A detailed analysis of the pastures was made in September, 1932. On comparison with the analysis carried out 2½ years

before it was found that bent, Yorkshire fog and white clover had increased to a marked extent, whilst other species such as perennial rye-grass, crested dogstail and rough-stalked meadow grass had decreased. The total number of tillers per unit of area was much less in 1932 than 1930. This latter result is probably due to the time of year at which the analysis was made. Cocksfoot showed a slight increase in its percentage contribution in 1932 due to the smaller number of total tillers per unit of area, but actually the number of tillers had decreased to the extent of 20 per cent. Other unsown grasses and miscellaneous weeds had also decreased in number whilst Italian rye-grass, timothy and red clover had completely disappeared.

TABLE VI.

Showing the number of tillers of certain species of the different pastures in September, 1932, compared with that of the "four weeks' rest" pasture, which is placed at 100. (The figures in brackets were the figures obtained in March, 1930).

	Pasture rested for		
	4 weeks.	*2 weeks.*	*4 days.*
(*a*) Cocksfoot ...	100	43 (60)	82 (47)
Yorkshire fog ...	100	112 (79)	114 (92)
Bent ...	100	105 (102)	115 (168)
Crested dogstail ...	100	116 (108)	126 (102)
Rough-stalked meadow grass ...	100	162 (105)	380 (79)
Wild white clover ...	100	144 (111)	148 (116)
Miscellaneous weeds ...	100	122 (161)	153 (191)
Total tillers ...	100	105 (105)	117 (119)
(*b*) Indigenous cocksfoot ...	100	73	52
Commercial cocksfoot ...	100	4	9
(*c*) Cocksfoot where sown ...	100	60	44
Cocksfoot where not sown ...	100	1.4	0.3

The effect of the grazing management on the various species of grasses and clovers forming the swards is shown in Table VI. In this table the number of tillers of each species in the pastures is calculated relative to the number in the "four weeks' rest" pasture which is placed at 100.

The most striking feature is that cocksfoot is the only species present in any quantity in the sward which shows fewer tillers on the frequently grazed pasture. This decrease in the number of tillers of cocksfoot is very marked; the "two weeks' rest" pasture having 43 per cent. and the "four days' rest" pasture having only 82 per cent. of the number of tillers present on the "four weeks' rest" pasture. Yorkshire fog, bent and crested

dogstail show a tendency to an increase in number of tillers on the areas receiving the short rest periods, though the 1930 analysis showed Yorkshire fog to have the opposite tendency. Wild white clover, miscellaneous weeds and rough-stalked meadow grass show a far greater increase in the number of "tillers" on the areas receiving the shorter periods of rest between successive grazings as compared with the "four weeks' rest" pasture. In the case of rough-stalked meadow grass the 1930 results seemed to show that it decreased on the frequently grazed pasture, but since that time the amount of this grass has decreased to the extent of over 75 per cent. and this decrease has been much more pronounced on the longer rested pastures.

Taking into account all the species, it is seen that the "two weeks' rest" pasture gave 5 per cent. more and the "four days' rest" pasture gave 17 per cent. more tillers than the "four weeks' rest" pasture. This agrees with the figures obtained in 1930.

Another interesting comparison is that of the effect of grazing management on different strains of cocksfoot. As mentioned earlier in this paper the trial was conducted on several seeds mixture plots containing different species and also different strains of grasses, each being included to the same extent on the three grazing systems. The figures in Table VIb show that by grazing the pastures often the number of tillers of commercial cocksfoot was reduced to as low as 4 per cent. and 9 per cent. of the number present on the pastures receiving four weeks' rest between successive grazings, whilst the number for indigenous cocksfoot was only reduced to 78 per cent. and 52 per cent on the "two weeks' rest" and "four days' rest" pastures respectively. Thus, whereas both strains of cocksfoot have been considerably reduced by frequent grazing, the commercial cocksfoot has suffered far more than the indigenous cocksfoot.

The figures for cocksfoot in Table VI take into account all the plots whether cocksfoot was sown in them or not. When the plots are grouped into (1) those where cocksfoot was sown; (2) those where no cocksfoot was sown, different figures are obtained as shown in Table VIc. These figures suggest that on the "four weeks' rest" pasture the cocksfoot on the cocksfoot-sown plots has been able to re-seed itself to some extent. These seeds were dispersed to adjoining plots as the result of the roaming of the sheep. On the other two pastures it is probable that little or no seed was allowed to be formed on account of the sheep grazing at such frequent intervals and thus there has been no contamination on the adjoining plots where no cocksfoot was

sown. This probably explains to some extent the high figures obtained for cocksfoot on the " four weeks' rest " pasture relative to the numbers found on the other two pastures, and especially so for the commercial cocksfoot which is so apt to throw up panicles when given a comparatively long period of rest.

Summary and Conclusions.

The first and second year data which have already been published (6) are confirmed by the third and fourth year data submitted in the present paper. The results may be summarized as follows :—

(1) The pasture receiving four weeks' rest between successive grazings has given a greater increase in live weight of sheep, and also it has carried more sheep per acre than the pasture which had only four days' rest between successive grazings. The " two weeks' rest " pasture was intermediate in its production. It yielded nearly as much live weight increase as the " four weeks' rest " pasture, but its carrying capacity (for sheep grazing days) was not much higher than the " four days' rest " pasture.

(2) The management of the pastures in one year had a marked effect on growth of herbage in the following spring. The pasture rested for a period of four weeks between successive grazings showed far more vigorous growth the following spring than the pastures receiving shorter intervals of rest : a result which was borne out by the early spring live weight increase.

(3) The composition of the sward depends largely on the grazing management which it receives. Certain grasses such as cocksfoot thrive very well when given long rest periods between successive grazings, whilst they give poor results when grazed often. This is far more marked in the case of commercial than of indigenous cocksfoot. Other grasses have not been differentially affected to an appreciable extent by the three systems of grazing adopted, whilst still others such as bent, white clover, and certain weeds have increased in number far more on the " four days' rest " pasture than on the pastures receiving longer rest periods.

The above data show conclusively that the grazing management of a pasture determines very largely the type of sward produced and the vitality of its components, whilst the value of these swards is reflected in the amount of live weight increase and the grazing days provided by them.

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THE EFFECT OF MILLING ON SAINFOIN SEED.

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After threshing, the Sainfoin seed is enclosed within the husk which is a practically indehiscent pod, through which the sprout has to make its way on germination. Many of these pods may be unripe or empty, and may also be mixed with "seeds" of such weeds as burnet. To remove the husk, burnet and inert matter, the pods are milled. Wittmack points out that although milled seed germinates more quickly it does not retain its vitality so long. Therefore milling has been practised with two objects in view, that of obtaining pure seed and higher and quicker germination. On the other hand, after some seasons, when the weather is not favourable for ripening, the seeds are liable to be damaged or cracked in the course of milling. For the purpose of estimating the effect of milling on laboratory germination and field establishment, milled and unmilled samples from the same 1930 crop were tested in 1931.

In the spring, eight different lots of seed were obtained from firms dealing in Sainfoin. One part of each lot was milled and

the other unmilled. The milled portions were again divided, and the husk of one half removed by rubbing between two rubber covered boards. Each lot was now divided into (*a*) unmilled, (*b*) rubbed by hand, and (*c*) milled portions, from the same original unmilled seed.

TABLE I.

Result of germination test at the Official Seed Testing Station, Cambridge.

Lots 1, 2, and 3 were started on March 17, 1931.
Lots 4, 5, 6, 7, and 8 were started on May 4, 1931.

No. of Lot.	*Description.*	*Treatment of seed.*	*Germination percentage.*			*Hard seed per cent.*	*Broken growths per cent.*
			6 days.	*14 days.*	*27 days.*		
1a	English Common ...	Unmilled.	4	27	38	16	0
1b	English Common ...	Rubbed.	18	39	44	12	0
1c	English Common ...	Milled.	37	65	69	4	0
2a	English Common ...	Unmilled.	21	50	62	29	0
2b	English Common ...	Rubbed.	27	56	66	14	0
2c	English Common ...	Milled.	68	78	86	0	0
3a	Cotswold Common ...	Unmilled.	29	47	57	24	0
3b	Cotswold Common ...	Rubbed.	43	69	77	8	0
3c	Cotswold Common ...	Milled.	33	59	64	1	0
			7 days.				
4a	Hampshire Common ...	Unmilled.	42	60	68	16	0
4b	Hampshire Common ...	Rubbed.	47	63	71	9	0
4c	Hampshire Common ...	Milled.	51	71	73	4	0
5a	Hampshire Common ...	Unmilled.	21	42	54	32	0
5b	Hampshire Common ...	Rubbed.	30	50	61	29	0
5c	Hampshire Common ...	Milled.	34	46	—	3	8
6a	Hampshire Common ...	Unmilled.	62	69	—	1	6
6b	Hampshire Common ...	Rubbed.	65	73	—	1	8
6c	Hampshire Common ...	Milled.	48	53	—	0	9
7a	Cotswold Common ...	Unmilled.	23	42	51	10	0
7b	Cotswold Common ...	Rubbed.	87	51	60	15	0
7c	Cotswold Common ...	Milled.	57	70	—	2	8
8a	French Giant ...	Unmilled.	44	68	74	9	0
8b	French Giant ...	Rubbed.	80	50	54	9	0
8c	French Giant ...	Milled.	64	76	—	0	0

Laboratory Tests.

Samples of each three portions of the eight lots were sent to the Official Seed Testing Station where the germination test was carried out. The results of this test are shown in Table I.

It will be seen from Table I that in lots 1, 2, 3, 4, 7 and 8 the effect of milling was to increase the percentage germination of the seed. In lots 5 and 6 rubbing gave a higher germination than milling while the milled portion of lot 6 showed a lower percentage of viable seeds than the unmilled. This lot 6 had the least number of hard seeds and the highest number of broken growths so it is probable that the seeds of these lots were softer and consequently more seriously damaged in the milling process.

Taking all the lots, the number of hard seeds was highest in the unmilled and lowest in the milled seeds, whilst the number of hard seeds in the rubbed seed was not considerably lower than in the unmilled.

It seems then that milling tends to induce broken growths and to reduce the number of hard seed.

Field Tests.

Identical samples were reserved for sowing at the trial grounds at Cardiff.

Particulars of the time of sowing and the condition of the soil and state of the weather are given in Table II.

TABLE II.

Lots.	*Sowing.*	*Date.*	*Condition of soil.*	*Weather.*
1, 2, & 3	First.	Mar. 25	Good.	Fine.
1, 2, & 3	Second.	Apr. 13	Good.	Fine.
1, 2, & 3	Third.	Apr. 30	Rather wet.	Fine.
1, 2, & 3	Fourth.	May 13	Rather wet.	Rain came on after sowing.
1, 2, & 3	Fifth.	May 27	Good.	Fine when sowing, but very heavy thunderstorm after.
4, 5, 6, 7, & 8	First.	June 4	Wet.	Fine.
4, 5, 6, 7, & 8	Second.	June 30	Dry.	Fine.

After sowing, the drills were covered with wire netting to keep off birds until the plants reached the pinnate leaf stage. Traps were also used against mice and such vermin. Counts were made almost daily for the first month and then at frequent intervals until they were fairly constant. It was noticed that a

count was sometimes smaller than the previous one, which indicates that casualties had occurred between the counts. These casualties were more frequent as the season advanced. As the plants were not removed at the time of counting, it is not possible

TABLE III.

Particulars of counts at various dates with different sowings.

a—Unmilled. b.—Rubbed. c—Milled.

Lot No.	*Sowing.*	*Date of sowing.*	*No. of days to first appearance.*	*No. of days to max. count.*	*Maximum count per cent.*	*No. of days to Sept. 30, 1931.*	*Per cent. No. of plants on Sept. 30, 1931.*	*Per cent. No. of plants on Oct., 1932.*
3a		25.3.31	17	102	76.5	187	67.3	62
3b	1st.	,,	16	102	77.4	187	68.6	64
3c		,,	16	102	53.3	187	41.7	39
3a		13.4.31	14	53	74.9	169	73.1	52
3b	2nd.	,,	14	53	79.0	169	76.1	50
3c		,,	15	84	51.5	169	40.2	36
3a		30.4.31	11	67	73.3	152	63.7	43
3b	3rd.	,,	11	67	77.7	152	74.1	53
3c		,,	11	67	48.9	152	42.5	33
3a		13.5.31	9	54	66.1	140	54.2	44
3b	4th.	,,	9	54	71.5	140	71.5	46
3c		,,	8	54	45.1	140	44.9	32
3a		27.5.31	7	73	68.6	127	67.	53
3b	5th.	,,	7	73	68.9	127	68.5	55
3c		,,	7	52	25.6	127	24.8	23
4a		4.6.31	7	19	41.1	120	33.3	28.6
4b	1st.	,,	7	44	58.2	120	56.7	48
4c		,,	7	22	40.0	120	39.0	29.2
4a		30.6.31	9	46	65.6	94	67.2	54.6
4b	2nd.	,,	9	60	75.0	94	75.	62.3
4c		,,	9	82	58.7	94	57.2	48
5a		4.6.31	7	65	58.7	120	59.8	45.8
5b	1st.	,,	7	72	64.5	120	64.	49.5
5c		,,	7	44	26.0	120	25.	28.4
5a		30.6.31	9	60	72.9	94	71.8	58.8
5b	2nd.	,,	9	53	71.4	94	71.3	58
5c		,,	9	82	29.1	94	29.1	26

to account for the total casualties as they may have been compensated to some extent by fresh appearances. Hence the totals for field germination may be too low.

The results in the field, typical examples of which are given in Table III, may be considered from the point of view of the time taken for the plants to appear above the ground and the maximum count as well as the time taken to reach it. As to the time of first appearances, there are often differences of one or two days in favour of milling the seed. When the day of first appearance was the same, more plants appeared from the rubbed and milled seed than from the unmilled. In the later sowings, the number of plants from the rubbed seed was greater than that from the milled seed on the day of first appearance. Considering the total germinations, in the case of the early sowings of lots 1 and 2 the milled seed showed a higher germination but lost this relative position in the case of the last sowing. The milled seed of lot 3 which tested low in the laboratory lost its viability in the field test very rapidly before the last sowing. In lots 4, 5, 7 and 8 there was an increase in the maximum counts with the later sowing of all treatments, but it was relatively smaller in the case of the milled seed whilst the rubbed seed kept its leading position in all these lots. This indicates that the milled seed lost its germinating power quicker than either the rubbed or the unmilled. This may be due to slight damage to the coat or to cracking of the seed.

All the drills were cut at the end of September, 1931, and the plants counted *in situ*. The hay and aftermath were again cut in 1932 and the plants were all dug up at the beginning of October and counted.

In September, 1931, quite a number of plants appeared to have germinated since the last count, but even then the number of plants surviving was seldom equal to the maximum count. In lot 1, the figures in both years agree fairly well with those of maximum field counts for the different sowings. In lot 2, the milled portion tended to drop behind the others in 1931 and much more so in 1932. At the end of the 1931 season in lot 3 the counts agreed well with the maxima, but in 1932 there was a greater divergence between the milled and the other two. In the case of lot 8, the 1932 count agreed better with the laboratory tests than with the previous field counts. The remaining lots agreed essentially with the maximum field counts. In all cases there was an appreciable reduction in the number of plants by 1932 even in the lots of Common Sainfoin.

Correlation between Laboratory and Field Results.

Lots 2 and 6 show a fair agreement between the two tests. The field results with lot 1 are somewhat variable. In lot 3

the germination of the milled seed was higher than that of the unmilled in the laboratory, and lower than both in the field. The milled seed of lot 4 gave the highest germination of the three in the laboratory but the lowest in the field. In lot 5, the milled gave lower count than the rubbed in 14 days and than both in 27 days at the Seed Testing Station, and in the field it was much lower than either. In both lots 7 and 8, whilst the milled seed gave the best performance in the laboratory, the rubbed seed did best in the field in 1931.

Perhaps it would not be fair to draw too definite conclusions from such a small number of lots but it appears that whilst milling does not invariably give better results in the laboratory, there is very little advantage in milling for field purposes apart from removal of burnet. When the seed is not quite well ripened and harvested in good condition, definite harm may result from milling. The fact that milled seed behaves differently from the rubbed shows that milling does more than remove the husk and that injury to the seed may occur. When the germination of an unmilled sample is low, the rate of sowing can be adjusted. For this reason a germination test is very essential in the case of Sainfoin, which is usually so variable.

Summary.

Milled, unmilled and rubbed seed of Sainfoin from the same lots were obtained from different seedsmen. Their germination was tested at the Official Seed Testing Station, Cambridge. Samples of these were also sown in field plots at Cardiff and counts of plants taken at different periods. At both centres the milling of the seed generally resulted in quicker germination. In the field, however, milling did not always result in the highest number of plants established as might be expected from the laboratory tests. It is suggested that in these instances milling had damaged the seed with a consequent reduction of the plants established in the field. Milling tended to reduce the percentage of hard seeds while increasing the number of broken growths.

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THE EFFECT OF A NURSE CROP ON THE ESTABLISHMENT AND FIRST YEAR YIELDS OF VARIOUS GRASSES AND CLOVERS WHEN SOWN IN PURE PLOTS AND IN MIXTURES.

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Introduction.

An investigation on the influence of a nurse crop carried out on clay soil in dry situations by Rhodin (1) in Denmark and referred to by Stapledon and Jones (2) showed that a nurse crop had a beneficial effect. Rhodin, however, concluded that this effect was due to the fact that the young seeds were protected by the nurse crop from drying out. Work on this problem at Aberystwyth reported on by Stapledon and Jones (2) produced evidence showing that a nurse crop favoured the establishment of the grasses and clovers by checking a too vigorous early growth of these species and so reducing inter-competition between species. Later work at Aberystwyth by Davies (3) showed that the effect of a nurse crop was to retard the development of the nursed seedlings, but that a cereal crop may prove a less aggressive competitor than the rye-grasses and so may have a beneficial effect on mixtures including these species by retarding their earlier growth. The present paper deals with an experiment designed primarily to test the effect of a nurse crop on various grasses and clovers both in pure plots and in certain seeds mixtures. The secondary part of the experiment consisted of the application of nitro-chalk at sowing time to some of the plots to test the effect of this manure on species sown both under a nurse crop and without a nurse crop.

Material and Methods.

For the purpose of this experiment an area of ground was divided into six blocks, each block containing 28 plots 1/600th acre in size, making a total of 168 plots. Half of this area, *i.e.*, three blocks, was sown under a nurse crop consisting of a mixture of barley and oats, while the other three blocks were sown without a nurse. In order to test the effect of nitrogenous manuring half the number of plots in each block were dressed with 100 lb. per acre of nitro-chalk at sowing time and with a similar amount two months after sowing.

The following species and strains were tested, together with seven mixtures :—Perennial rye-grass, Italian rye-grass, commercial cocksfoot, indigenous cocksfoot, timothy, meadow fescue,

rough-stalked meadow grass and Montgomery red clover. All species and mixtures, except indigenous cocksfoot and Mixture 7, were replicated six times; indigenous cocksfoot and Mixture 7 were replicated three times.

TABLE I.

Showing the effect of a nurse crop and also the effect of nitro-chalk, on establishment in the seeding year. The figures given represent the number of plants inside ten readings taken at random within a 6 inch. mesh.

Treatment.	*Perennial rye-grass.*	*Italian rye-grass.*	*Commercial cocksfoot.*	*Indigenous cocksfoot.*	*Timothy.*	*Meadow fescue.*	*Rough-stalked meadow grass.*	*Mont. red clover.*
No nurse+N	82	90	156	115	138	93	—	65
No nurse—N	131	119	188	216	167	119	188	60
Average	106	105	172	149	152	106	188	63
Nurse+N	95	69	91	77	100	96	165	57
Nurse—N	142	88	178	214	130	114	178	70
Average	118	79	135	123	115	105	171	63

Three months after sowing sheep were turned on to the no-nurse plots. The nurse plots were grazed by sheep after the corn crop had been harvested.

Counts were made on the plots by taking ten readings with the 6 inch x 6 inch mesh in the case of the pure species, while a percentage tiller estimation was made on the mixtures in the seeding year.

The following year the plots were put up to hay and cut in June. The green weight of each plot was ascertained and a 2 lb. sample taken from which the air-dry weight of the plots could be calculated and also a 1 lb. sample for botanical analysis. The plots were cut again in September for aftermath, and a similar technique adopted. Counts of plants and tillers were again made on the pure plots, but no botanical analysis was carried out on the mixtures for the first harvest year.

Discussion of results.

I. *The effect on species sown in pure plots.*

The figures in Table I show that in the majority of species tested there has been a reduction in establishment due to the nurse crop. Meadow fescue and Montgomery red clover show no effect, while perennial rye-grass seems to have benefited by the use of a nurse crop. The application of nitro-chalk has resulted in a reduction in establishment except in the case of Montgomery red clover, which shows an increase in establishment under a nurse crop as a result of an application of this manure.

The results shown in Table I are confirmed by the figures presented in Table II, which relate to counts of plants and tillers made in the following year, namely, the first harvest year.

Table II shows that there has been considerable winter-killing in the majority of species; commercial cocksfoot and Italian rye-grass having fared worst. Perennial rye-grass, however, shows an improvement in establishment under a nurse crop but a decrease when sown without a nurse crop and without nitro-chalk. The application of nitro-chalk as shown from the figures in Table II has resulted in less winter-killing. Thus nitro-chalk is seen to have had a beneficial effect in the first harvest year.

A study of Table III shows the effect of the treatments on the yield of the species. The figures show that the yields in the case of perennial rye-grass, commercial cocksfoot, timothy and meadow fescue have not been affected by the nurse crop. Italian rye-grass has benefited considerably and Montgomery red clover slightly by the use of a nurse crop, while indigenous cocksfoot has

TABLE II.

Showing the effect of a nurse crop and also the effect of nitro-chalk on establishment in the first harvest year. The figures represent the number of plants and tillers inside ten readings taken within a 6 inch mesh.

	Perennial rye-grass.		*Italian rye-grass.*		*Commercial cocksfoot.*		*Indigenous cocksfoot.*	
Treatment.	*Plants*	*Tillers*	*Plants*	*Tillers*	*Plants*	*Tillers*	*Plants*	*Tillers*
No-nurse+N	118	879	62	261	86	436	125	849
No-nurse—N	93	548	32	130	85	384	101	963
No-nurse	105	713	47	195	85	410	113	906
Nurse+N	126	1183	50	302	63	384	65	815
Nurse—N	121	903	43	190	91	342	65	992
Nurse	123	1043	46	246	77	363	65	903

	Timothy.		*Meadow fescue.*		*Rough-stalked meadow grass.*		*Montgomery red clover.*	
Treatment.	*Plants*	*Tillers*	*Plants*	*Tillers*	*Plants*	*Tillers*	*Plants*	*Tillers*
No-nurse+N	100	468	89	337	—	1375	47	—
No-nurse—N	125	406	76	314	—	1780	58	—
No-nurse	112	434	82	325	—	1577	52	—
Nurse+N	65	381	71	373	—	1590	42	—
Nurse—N	83	341	92	400	—	1650	55	—
Nurse	74	361	81	385	—	1620	48	—

suffered; rough-stalked meadow grass has been very slightly affected. The effect of a dressing of nitro-chalk is very marked on some of the species, particularly under a nurse crop. Commercial cocksfoot and meadow fescue show an increase in yield as a result of a dressing of nitro-chalk, both with and without a nurse crop, whereas perennial rye-grass, Italian rye-grass, indigenous cocksfoot and timothy show an increase in yield under a nurse crop, while without a nurse crop there is no increase in

yield following an application of this manure. Although the figures show an increase in yield of Montgomery red clover as a result of an application of nitro-chalk, this increase is not great enough to permit of a definite pronouncement on this point.

TABLE III.

Showing the effect of a nurse crop and also the effect of nitro-chalk on the net air dry yield in cwt. per acre of hay + aftermath in the first harvest year for each species tested.

Treatment.	*Perennial rye-grass.*	*Italian rye-grass.*	*Commercial cocksfoot.*	*Indigenous cocksfoot.*	*Timothy.*	*Meadow fescue.*	*Rough-stalked meadow grass.*	*Mont. red clover.*
No-nurse+N	53.17	32.37	51.83	48.00	32.47	50.56	14.40	66.51
No-nurse—N	51.11	34.47	41.81	40.06	28.38	40.90	10.47	58.79
No-nurse	52.4	33.41	46.83	44.03	30.43	45.78	12.61	60.98
Nurse+N	60.67	56.20	56.18	36.40	36.09	50.62	18.56	72.87
Nurse—N	42.74	40.43	38.44	24.20	22.53	37.96	18.98	65.77
Nurse	51.70	48.31	47.30	30.30	29.31	44.29	18.77	68.65

II. *The effect on species sown in certain seeds mixtures.*

The seeds mixtures tested are shown in Table IV.

TABLE IV.

Showing the species and seed rate in lb. per acre used in the seeds mixtures tested.

Species.	*Mixture 1*	*Mixture 2*	*Mixture 3*	*Mixture 4*	*Mixture 5*	*Mixture 6*	*Mixture 7*
Italian rye-grass ...	—	—	6	18	—	10	—
Perennial rye-grass ...	—	—	—	—	14	14	—
Cocksfoot ...	—	10	10	10	—	—	—
Timothy ...	4	4	4	4	—	—	—
Meadow fescue ...	10	10	10	10	—	—	—
Crested dogstail ...	2	2	2	2	—	—	—
Rough-stalked meadow grass ...	2	2	2	2	4	4	—
Montgomery red clover	4	4	4	4	4	4	—
Wild white clover ...	2	2	2	2	3	3	—
Burnet ...	—	—	—	—		—	30
Ribgrass ...	—	—	—	—	—	—	30

The result of the botanical analyses made in the seeding year is given in Appendix I, in which the actual number of tillers of each species is indicated, together with the total number of tillers per ten readings taken inside a square mesh 6 inch x 6 inch and also the percentage estimation of bare ground and ground covered by moss.

Table V consists of figures obtained from an average of Appendix I.

Table V shows that there has been a reduction in the number of tillers of all species as a result of the use of a nurse crop; the greatest reduction being in the case of wild white clover, unsown legumes and weeds, while cocksfoot and unsown grasses have not been greatly affected by the use of a nurse crop. Table V also shows that there is a considerable increase in bare ground and ground covered by moss resulting from the use of a nurse crop. An application of nitro-chalk has resulted in a decrease in the number of tillers of timothy, crested dogstail, Montgomery red clover, wild white clover and weeds, while cocksfoot, meadow fescue, rough-stalked meadow grass, unsown legumes and unsown grasses seem to have benefited from an application of this manure. The amount of bare ground has been reduced by the use of nitro-chalk.

The effect of treatments on the gross yield, net yield of sown species and also the individual yield of species in cwt. per acre as hay and aftermath in the first harvest year is shown in Appendix II.

TABLE V.

Showing the relative number of tillers produced under various treatments.

	(a) *Tillers produced under a nurse crop relative to no-nurse placed at 100.*	(b) *Tillers produced as a result of an application of nitro-chalk relative to no nitro-chalk at 100.*
Perennial rye-grass ...	78.9	98.0
Italian rye-grass ...	78.5	86.9
Cocksfoot ...	94.8	111.3
Timothy ...	73.5	60.0
Meadow fescue ...	84.9	114.6
Crested dogstail ...	73.4	67.2
Rough-stalked meadow grass ...	82.0	110.0
Montgomery red clover ...	77.4	70.6
Wild white clover ...	36.4	78.4
Other legumes ...	46.0	117.4
Other grasses ...	90.4	128.8
Weeds ...	57.7	78.7
Total tillers ...	74.7	95.7
Bare ground ...	171.3	84.3
Ground covered by moss ...	133.3	110.3

The figures shown in Table VI were obtained from an average of the weights given in Appendix II.

TABLE VI.

Showing the relative yield produced under various treatments.

	(a) *Yield produced under a nurse crop relative to no nurse at 100.*	(b) *Yield produced as a result of an application of nitro-chalk relative to no nitro-chalk at 100.*
Perennial rye-grass ...	110.2	96.3
Italian rye-grass ...	131.1	91.2
Cocksfoot ...	122.0	130.9
Timothy ...	89.8	91.7
Meadow fescue ...	93.9	109.6
Crested dogstail ...	52.7	88.3
Rough-stalked meadow grass ...	117.5	75.8
Montgomery red clover ...	95.6	106.5
Wild white clover ...	67.0	124.1
Other legumes ...	100.0	100.0
Other grasses ...	106.4	83.3
Weeds ...	136.1	59.1
Total yield ...	105.1	102.0
Net yield of sown species ...	104.1	103.9

Table VI shows that the nurse crop has not had any appreciable effect on either the gross yield or the net yield of sown species, but with reference to the individual yield of species it is seen that the yields of crested dogstail and wild white clover have been reduced as a result of the use of a nurse crop, while

TABLE VII.

Showing the yield in cwt. per acre of hay and aftermath of each species, together with the seed rate in lb. per acre.

	Perennial rye-grass.		*Italian rye-grass.*		*Cocksfoot.*		*Timothy.*		*Meadow fescue.*	
	Seed rate in lb. per acre.	*Yield in cwt. per acre (air dry).*	*Seed rate in lb. per acre.*	*Yield in cwt. per acre (air dry).*	*Seed rate in lb. per acre.*	*Yield in cwt. per acre (air dry).*	*Seed rate in lb. per acre.*	*Yield in cwt. per acre (air dry).*	*Seed rate in lb. per acre.*	*Yield in cwt. per acre (air dry).*
Mixture 1 ...	—	—	—	—	—	—	4	7.98	10	27.28
Mixture 2 ...	—	—	—	—	10	21.39	4	3.37	10	14.68
Mixture 3 ...	—	—	6	15.93	10	12.61	4	1.52	10	7.51
Mixture 4 ...	—	—	18	21.93	10	8.47	4	0.95	10	4.01
Mixture 5 ...	14	43.88	—	—	—	—	—	—	—	—
Mixture 6 ...	14	33.03	10	7.04	—	—	—	—	—	—

the yields of Italian rye-grass, cocksfoot, Montgomery red clover, rough-stalked meadow grass and weeds have been increased by this treatment.

Considering the effect of an application of nitro-chalk, Table VI shows that cocksfoot and wild white clover have benefited by the use of this manure, whereas the yields of crested dogstail, rough-stalked meadow grass and weeds have been depressed.

III. *The effect of competition on the yield of individual species.*

Table VII shows the average yield per acre of certain species, together with the seed rate in lb. per acre.

A study of Table VII illustrates the effect of competition on the yields of certain species. Both meadow fescue and timothy suffer considerably from competition with grasses such as Italian rye-grass and cocksfoot as shown by their rapid decrease in yield. Also the competitive effect of Italian rye-grass on cocksfoot is shown by the reduction in yield from 21.39 cwt. to 12.61 cwt. when Italian rye-grass is included in the mixture to the extent of 6 lb., while a further reduction in yield to 8.47 cwt. is recorded when it is included to the extent of 18 lb. These figures confirm previous work carried out at Aberystwyth by Davies (3).

Conclusions.

I. *The effect of the nurse crop.*

From the data collected in the seeding year it is seen that the nurse crop has a depressing effect on establishment as shown by a reduction in the number of plants and tillers. Another important point in connection with this problem is the higher percentage of bare ground resulting from the use of a nurse crop. It may, therefore, be said that a nurse crop hinders the formation of a close sward, and although in the seeding year the nurse crop may depress weeds the open sward resulting from this treatment presents ideal conditions for the rapid spread of weeds subsequently, as illustrated by the figure obtained in the first harvest year, which shows a higher yield of weeds on the nurse plots than on the no-nurse plots. Nevertheless the higher percentage of weeds on the no-nurse plots in the seeding year may result in the reduction in size of plants of sown species under this treatment due to competition, and so adversely affect the yield in the first harvest year. This statement is borne out by data obtained in the first harvest year, which show that there is comparatively no difference in the yields under the two treatments, although the counts of plants and tillers show that there are more plants and tillers on the no-nurse plots. With reference to the effect of a nurse crop on individual species, perennial rye-grass when sown in pure plots appears to benefit by this treatment both as regards number of plants and yield, although when

sown in a seeds mixture the number of tillers is reduced by this treatment, but the yield is not greatly affected. Italian rye-grass shows a reduction in the number of plants and tillers in the seeding year when sown both in pure plots and in mixtures, but in the first harvest year there is no difference in the number of plants as a result of the use of a nurse crop, although the yield in the first harvest year shows a considerable increase resulting from this treatment. This increase in yield may be explained by the fact that the no-nurse plots were grazed earlier than the nurse plots, and this may have hindered the development of the plants in the seeding year and so affected their size in the first harvest year. Cocksfoot, both commercial and indigenous, shows a reduction in the number of plants when sown in pure plots in both the seeding year and the first harvest year, but when sown in a seeds mixture the reduction is insignificant. The yield of this species, however, seems to have been reduced by this treatment when sown in pure plots, but when sown in a mixture the yield tends towards an increase. The number of tillers of timothy, both in pure plots and in seeds mixtures, is reduced by the use of a nurse crop. The yield when sown in pure plots has not been affected, but in seeds mixtures it has been slightly reduced. The use of a nurse crop has not had any significant effect on first harvest year yields in meadow fescue and Montgomery red clover, but there is a marked depression in the number of tillers in the seeding year. The number of tillers and first harvest year yield of crested dogstail and wild white clover have been adversely affected by the use of a nurse crop when sown in a seeds mixture, while rough-stalked meadow grass has benefited. The effect of a nurse crop on weeds shows a reduction in the number of tillers in the seeding year, but an increase in yield of weeds is recorded in the first harvest year.

II. The effect of nitro-chalk.

As regards the total yield of mixtures no benefit has been derived from an application of nitro-chalk; in the case of individual species cocksfoot and meadow fescue benefit by its use, while there is a reduction in weeds. On account of the high weed content of Mixture 7, the figures for this mixture have been excluded from the tables.

Summary.

The results obtained in the present experiment indicate that a nurse crop

(1) Has had a beneficial effect on perennial rye-grass when sown in pure plots, but a detrimental effect on that species when included in seeds mixtures;

(2) Has not had any significant effect on first harvest year yields of meadow fescue and Montgomery red clover, but has caused a marked reduction in the number of tillers;

(3) Has had a detrimental effect on crested dogstail and wild white clover;

(4) Has been responsible for a higher percentage of bare ground and has hindered the formation of a close sward in the seeding year;

(5) Has had no significant effect on first harvest year yields of hay and aftermath.

An application of nitro-chalk at the time of sowing was followed by a reduction in weeds, but total yield in the first harvest year was not affected materially.

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APPENDIX I.

Showing the actual number of tillers of each species, together with the total number of tillers per ten readings taken inside a square mesh 6 inch x 6 inch, and also the percentage estimation of bare ground and ground covered by moss in the seeding year.

Mixture.	Treatments.	Actual Number of Tillers of Each Species.												Total No. of Tillers.	Percentage Estimation.	
		Perennial rye-grass.	Italian rye-grass.	Cocksfoot.	Timothy.	Meadow fescue.	Crested dogtail.	Rough stalked meadow grass.	Mont. red clover.	Wild white clover.	Other legumes.	Other grasses.	Weeds.		Bare ground.	Ground covered by moss.
1	No-nurse + N	—	—	—	26.5	173.5	9.0	63.0	33.5	64.0	5.0	131.0	92.0	597.5	34.7	1.0
	,, — N	—	—	—	56.5	139.5	23.5	50.5	40.0	132.0	5.5	141.0	124.0	712.5	28.5	0.5
	Average	—	—	—	41.5	156.5	16.3	57.7	36.7	98.0	5.3	136.0	108.0	655.0	31.6	0.8
	Nurse + N ..	—	—	—	15.0	131.0	12.5	52.5	20.5	29.5	7.0	85.5	51.5	405.0	59.7	1.0
	,, — N ..	—	—	—	43.5	123.0	19.0	65.0	36.5	43.5	8.5	86.5	69.5	495.0	52.0	0.8
	Average ..	—	—	—	29.2	127.0	15.8	58.7	28.5	36.5	7.8	86.0	60.5	450.0	55.9	0.9
2	No-nurse + N	—	—	165.5	27.0	135.5	12.0	45.5	32.0	43.5	14.5	70.0	89.5	635.0	35.2	0.8
	,, — N	—	—	184.5	37.5	130.0	15.0	80.5	50.0	107.5	12.5	76.0	139.0	832.5	23.5	0.5
	Average	—	—	175.0	32.3	132.7	13.5	63.0	41.0	75.5	13.5	73.0	114.2	733.7	29.2	0.6
	Nurse + N ..	—	—	138.0	10.0	129.5	3.5	36.5	14.0	15.5	2.0	119.0	34.5	502.5	51.0	1.0
	,, — N ..	—	—	115.5	22.5	87.5	13.5	43.5	33.0	34.0	1.5	95.5	76.0	522.5	48.7	1.5
	Average	—	—	126.7	16.3	108.5	8.5	40.0	23.5	24.8	1.8	107.2	55.2	512.5	49.9	1.3
3	No-nurse + N	—	225.0	77.0	12.5	58.5	11.0	42.0	22.0	42.0	8.0	35.5	86.5	620.0	32.7	0.8
	, — N	—	295.5	105.0	10.5	53.0	16.0	42.0	34.0	60.0	2.5	45.0	69.0	732.5	34.0	1.3
	Average	—	260.2	91.0	11.5	55.7	13.5	42.0	28.0	51.0	5.3	40.3	77.7	676.2	33.4	1.0
	Nurse + N ..	—	188.0	120.0	15.0	53.0	14.0	33.0	18.0	20.5	2.0	63.0	33.5	560.0	47.0	0.8
	,, — N ..	—	163.5	75.5	12.0	56.5	5.0	44.0	26.0	29.5	7.0	39.0	62.0	520.0	59.7	1.3
	Average	—	175.7	97.7	13.5	54.8	9.5	38.5	22.0	25.0	4.5	51.0	47.8	540.0	53.4	1.0

APPENDIX I.—Continued.

Mixture.	Treatments.	Actual Number of Tillers of Each Species. Perennial rye-grass.	Italian rye-grass.	Cocksfoot.	Timothy.	Meadow fescue.	Crested dogtail.	Rough stalked meadow grass.	Mont. red clover.	Wild white clover.	Other legumes.	Other grasses.	Weeds.	Total No. of Tillers.	Percentage Estimation. Bare ground.	Ground covered by moss.
4	No-nurse + N	—	335.0	60.5	5.0	30.5	6.5	27.0	23.0	47.5	16.5	45.5	63.0	660.0	30.2	1.3
	,, — N	—	431.0	39.5	12.0	35.5	6.0	50.0	39.5	75.5	8.0	41.5	51.5	790.0	28.0	1.2
	Average	—	383.0	50.0	8.5	33.0	6.3	38.5	31.2	61.5	12.3	43.5	57.2	725.0	29.1	1.2
	Nurse + N ..	—	359.0	87.5	11.0	35.0	0.5	35.0	20.5	13.0	1.0	50.5	22.0	635.0	36.5	1.0
	,, — N ..	—	303.5	62.5	8.5	26.5	4.5	25.5	10.0	15.0	3.0	37.5	56.0	552.5	50.5	1.0
	Average	—	331.2	75.0	9.8	30.7	2.5	30.2	15.3	14.0	2.0	44.0	39.0	593.7	43.5	1.0
5	No-nurse + N	421.5	—	—	—	—	—	124.5	27.5	98.5	5.5	75.5	84.5	837.5	22.7	0.8
	,, — N	438.5	—	—	—	—	—	67.5	23.0	52.5	7.0	59.0	60.0	707.5	33.5	0.8
	Average	430.0	—	—	—	—	—	96.0	25.3	75.5	6.3	67.2	72.2	772.5	28.1	0.8
	Nurse + N ..	370.5	—	—	—	—	—	67.0	28.0	35.5	6.5	79.5	30.5	617.5	38.5	1.3
	,, — N ..	382.0	—	—	—	—	—	34.5	44.0	30.5	3.5	46.0	39.5	580.0	53.5	0.8
	Average	376.2	—	—	—	—	—	50.8	36.0	33.0	5.0	62.7	35.0	598.7	46.0	1.0
6	No-nurse + N	268.5	217.0	—	—	—	—	83.0	45.0	92.0	13.0	111.5	65.0	895.0	19.5	0.8
	,, — N	268.0	290.0	—	—	—	—	30.0	35.5	61.0	6.0	46.0	56.0	792.5	24.2	0.8
	Average	268.2	253.5	—	—	—	—	56.5	40.3	76.5	9.5	78.7	60.5	843.7	21.9	0.8
	Nurse + N ..	176.0	191.0	—	—	—	—	66.5	14.0	24.5	1.0	57.5	29.5	560.0	49.7	2.5
	,, — N ..	173.5	204.0	—	—	—	—	76.0	49.0	28.0	5.0	33.5	61.0	630.0	46.7	1.5
	Average	174.7	197.5	—	—	—	—	71.2	31.5	26.3	3.0	45.5	45.3	595.1	48.2	2.0

APPENDIX II.

Showing the contribution in cwt. per acre of each species, together with the total yield and net yield of sown species under various treatments, in the first harvest year.

Mixture.	Treatments.	Actual Yield in Cwt. per Acre of Individual Species.												Total yield.	Net yield of sown species.
		Perennial rye-grass.	Italian rye-grass.	Cocks-foot.	Tim-othy.	Meadow fescue.	Crested dogstail.	Rough stalked meadow grass.	Mont. red clover.	Wild white clover.	Other legumes.	Other grasses.	Weeds.		
1	No-nurse + N	—	—	—	7.01	32.33	1.13	1.52	24.23	0.51	Trace	3.69	1.78	72.20	66.73
	,, — N	—	—	—	9.50	25.56	1.34	2.16	22.12	1.00	Trace	3.63	2.15	67.46	61.68
	Average	—	—	—	8.25	28.94	1.24	1.84	23.17	0.76	Trace	3.66	1.97	69.83	64.20
	Nurse + N	—	—	—	8.07	26.91	0.42	2.23	28.15	0.65	Trace	3.11	1.84	71.38	66.43
	,, — N	—	—	—	7.37	24.36	0.76	2.72	23.91	0.78	Trace	1.78	4.16	65.84	59.90
	Average	—	—	—	7.72	25.63	0.59	2.47	26.03	0.72	Trace	2.45	3.00	68.61	63.16
2	No-nurse + N	—	—	21.98	4.03	15.84	1.79	0.92	22.36	2.27	Trace	0.79	0.98	70.96	69.19
	,, — N	—	—	17.64	3.80	14.63	1.21	1.56	18.55	0.67	Trace	1.27	1.37	60.70	58.06
	Average	—	—	19.81	3.92	15.23	1.50	1.24	20.45	1.47	Trace	1.03	1.18	65.83	63.62
	Nurse + N	—	—	26.94	2.33	14.96	0.68	2.23	18.76	0.53	Trace	1.87	2.03	70.33	66.43
	,, — N	—	—	19.01	3.32	13.31	0.95	2.22	18.88	0.60	Trace	2.91	3.65	64.85	58.29
	Average	—	—	22.97	2.82	14.13	0.82	2.23	18.82	0.57	Trace	2.39	2.84	67.59	62.36
3	No-nurse + N	—	14.28	11.27	1.47	6.23	1.89	0.62	20.73	0.75	—	0.56	1.20	59.00	57.24
	,, — N	—	16.48	9.42	1.15	6.39	1.68	1.09	19.65	0.71	—	1.27	1.55	59.39	56.57
	Average	—	15.38	10.34	1.31	6.31	1.78	0.86	20.19	0.73	—	0.92	1.37	59.19	56.90
	Nurse + N	—	18.19	17.68	1.59	7.57	0.39	0.76	21.95	0.38	—	1.15	0.73	70.39	68.51
	,, — N	—	14.79	12.09	1.89	9.87	1.21	1.25	22.51	0.64	Trace	1.57	2.20	68.02	64.25
	Average	—	16.49	14.88	1.74	8.72	0.80	1.01	22.23	0.51	Trace	1.36	1.46	69.20	66.38

APPENDIX II.—Continued.

Mixture.	Treatments.	Actual Yield in Cwt. per Acre of Individual Species.												Total yield.	Net yield of sown species.
		Perennial rye-grass.	Italian rye-grass.	Cocks-foot.	Tim-othy.	Meadow fescue.	Crested dogstail.	Rough stalked meadow grass.	Mont. red clover.	Wild white clover.	Other legumes.	Other grasses.	Weeds.		
4	No-nurse + N	—	20.40	8.46	1.39	4.25	1.18	0.80	22.52	0.95	Trace	0.98	0.90	61.83	59.95
	,, — N	—	22.19	7.81	0.85	5.14	1.75	0.97	21.53	1.03	—	1.46	0.85	63.58	61.27
	Average	—	21.29	8.13	1.12	4.69	1.47	0.89	22.02	0.99	Trace	1.22	0.88	62.70	60.60
	Nurse + N	—	27.32	10.07	0.59	3.79	0.76	0.54	18.40	0.34	Trace	1.40	0.63	63.84	61.81
	,, — N	—	29.83	7.56	0.99	2.85	1.21	1.01	23.13	0.52	Trace	1.28	1.44	69.82	67.10
	Average	—	28.57	8.81	0.79	3.32	0.99	0.78	20.76	0.43	Trace	1.34	1.04	66.83	64.46
5	No-nurse + N	40.84	—	—	—	—	—	1.26	24.93	1.47	Trace	0.61	0.88	69.99	68.50
	,, — N	42.79	—	—	—	—	—	0.81	22.31	1.16	—	1.15	1.49	69.71	67.07
	Average	41.81	—	—	—	—	—	1.04	23.62	1.31	Trace	0.88	1.19	69.85	67.78
	Nurse + N	45.14	—	—	—	—	—	0.43	25.15	2.50	Trace	0.61	0.51	74.24	73.12
	,, — N	46.67	—	—	—	—	—	0.90	19.59	0.82	Trace	0.81	0.74	69.63	68.08
	Average	45.95	—	—	—	—	—	0.66	22.37	1.66	Trace	0.71	0.63	71.98	70.60
6	No-nurse + N	29.32	3.08	—	—	—	—	0.81	31.45	1.51	—	0.59	0.51	67.27	66.17
	,, — N	31.82	6.67	—	—	—	—	1.17	26.36	1.47	Trace	0.93	1.03	69.45	67.49
	Average	30.57	4.88	—	—	—	—	0.99	28.90	1.49	Trace	0.76	0.77	68.36	66.83
	Nurse + N	35.86	8.16	—	—	—	—	0.72	20.57	0.61	Trace	0.80	0.91	67.63	65.92
	,, — N	35.12	10.26	—	—	—	—	1.06	23.64	0.52	Trace	0.74	1.22	72.56	70.60
	Average	35.49	9.21	—	—	—	—	0.89	22.10	0.57	Trace	0.77	1.06	70.09	68.26

SULPHATE OF AMMONIA COMPARED WITH NITRO-CHALK AS A NITROGENOUS FERTILIZER ON AN OPEN HILL *MOLINIA* PASTURE.

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Introduction.

Results of considerable significance have been obtained at Aberystwyth, reported on by Davies and Jones (1) on the manurial response on a typical hill *Molinia* pasture. These results show that a rapid change is brought about in the flora on the manured plots, particularly those receiving nitrogen in the form of nitro-chalk; the original *Molinia* pasture being transformed into a typical bent-fescue pasture, while an increase in yield was also recorded.

The present paper deals with a preliminary experiment designed to ascertain the effect of sulphate of ammonia compared with nitro-chalk on the botanical composition and yield of an open hill *Molinia* pasture. As the experiment was only of a preliminary nature and unreplicated, the results obtained are chiefly of value as indicating general tendencies.

Material and Methods.

A *Molinia* area, 10 ft. x 20 ft. was fenced in, the vegetation, which consisted chiefly of dead matter, having been previously burned. This area was halved and a 6 ft. x 6 ft. plot marked out in each half, leaving a 2 ft. border round each plot.

An initial application of superphosphate at 4 cwt. per acre was given to the whole area, and nitro-chalk at $1\frac{1}{2}$ cwt. per acre and sulphate of ammonia at $1\frac{1}{8}$ cwt. per acre to each respective plot. A clearing cut was made on June 1st, after which the plots were cut monthly; all defoliation being done by means of hand clippers. A dressing of nitro-chalk at 1 cwt. per acre and sulphate of ammonia at $\frac{3}{4}$ cwt. per acre was applied to each respective plot after each cut, excepting the last cut of the year, which was made on November 1st, when the dressing was increased to $1\frac{1}{2}$ cwt. per acre of nitro-chalk and $1\frac{1}{8}$ cwt. of sulphate of ammonia. After the November cut the plots were allowed to grow until June 1st in the following year. This gave the total yearly yield.

A botanical analysis was made before each cut on each plot. The method of analysis was similar to that used by Davies and Jones (1) and is carried out by taking ten readings at random with the 6 in. x 6 in. mesh on each plot; the percentage productivity (*i.e.*, percentage by weight) is estimated, ten marks are

given at each reading and these marks are allotted to each species present in proportion to its relative abundance (by weight). After cutting, the grass from each plot was placed in scrim bags and air-dried to a constant weight. The experiment was carried on for the second year and a similar technique adopted. As regards manures, no superphosphate was applied in the second year, but dressings of nitro-chalk and sulphate of ammonia were given as in the first year.

Results.

From the percentage productivity analysis and the monthly air dry yields, the actual yield of each species has been calculated and the figures obtained are given in Tables I and II.

TABLE I.

Showing actual air dry yield of each species per month and total yield for the year (1/6/30—30/5/31) in cwt. (=100 lb.) per acre; first year of treatment.

	Nitro-chalk.						
	Molinia	*Fine-leaved fescue*	*Bent*	Nardus and Triodia	*Weeds*	*Moss and inert matter*	*Total yield*
June ...	7.53	0.80	0.32	0.48	0.48	1.07	10.68
July ...	3.07	0.44	0.37	Trace	0.06	0.42	4.36
August ...	1.13	0.29	0.17	0.15	0.21	0.25	2.50
September ...	0.06	0.23	0.47	0.05	0.05	0.15	1.01
October ...	0.01	0.15	0.41	0.05	0.02	0.17	0.81
Winter growth ...	0.20	3.62	1.41	Trace	0.05	0.13	5.41
Total ...	12.30	5.53	3.15	0.73	0.87	2.19	24.77

	Sulphate of ammonia.						
	Molinia	*Fine-leaved fescue*	*Bent*	Nardus and Triodia	*Weeds*	*Moss and inert matter*	*Total yield*
June ...	11.18	1.07	0.22	0.50	0.43	0.93	14.33
July ...	4.93	1.07	0.31	0.07	0.24	0.28	6.90
August ...	1.86	0.77	0.48	0.17	0.29	0.11	3.68
September ...	0.10	0.50	0.55	0.02	0.11	0.20	1.48
October ...	0.01	0.47	0.26	0.03	0.05	0.26	1.08
Winter growth ...	0.28	1.19	0.08	0.03	Trace	0.12	1.70
Total ...	18.36	5.07	1.90	0.82	1.12	1.90	29.17

TABLE II.

Showing actual air dry yield of each species per month and total yield for the year (1/6/31—30/5/32) in cwt. (=100 lb.) per acre; second year of treatment.

	Nitro-chalk.						
	Molinia	*Fine-leaved fescue*	*Bent*	Nardus and Triodia	*Weeds*	*Moss and inert matter*	*Total yield*
June ...	0.46	0.84	7.63	0.09	0.09	0.19	9.30
July ...	1.15	1.37	3.40	0.06	0.12	0.13	6.23
August ...	0.10	0.80	3.06	0.02	0.04	0.08	4.10
September ...	Trace	0.45	2.63	0.02	0.02	0.08	3.20
October ...	—	0.07	0.55	Trace	Trace	0.02	0.64
Winter growth ...	Trace	0.57	5.55	—	0.13	0.13	6.38
Total ...	1.71	4.10	22.82	0.19	0.40	0.63	29.85

	Sulphate of ammonia.						
	Molinia	*Fine-leaved fescue*	*Bent*	Nardus and Triodia	*Weeds*	*Moss and inert matter*	*Total yield*
June ...	4.20	2.18	0.65	0.04	—	0.18	7.25
July ...	5.33	1.14	0.17	—	Trace	0.07	6.71
August ...	0.76	1.58	0.27	0.09	—	0.15	2.85
September ...	0.04	0.83	0.11	0.01	—	0.13	1.12
October ...	Trace	0.23	0.06	Trace	Trace	0.05	0.34
Winter growth ...	0.27	1.89	0.20	0.01	Trace	0.13	2.50
Total ...	10.60	7.85	1.16	0.15	Trace	0.71	20.77

A study of Table I (first year) shows that there is a greater yield of *Molinia* under the sulphate of ammonia treatment than under the nitro-chalk treatment, while the figures for bent show a greater yield under the nitro-chalk treatment than under the sulphate of ammonia treatment. As regards total yield, the greater yield is derived from the sulphate of ammonia plot.

The results are more marked in the second year. The figures in Table II show that there is a much higher yield of *Molinia* under the sulphate of ammonia treatment than under the nitro-chalk treatment, but compared with the previous year's figures

there has been a reduction in the yield of this species under both treatments, but a greater reduction is recorded under the nitro-chalk treatment. Also fine-leaved fescue shows a higher yield on the sulphate of ammonia plot than on the nitro-chalk plot. Bent, however, shows a very marked response to an application of nitro-chalk, while practically no response is recorded under the sulphate of ammonia treatment. From a comparison of the figures given for total yield Table II shows that in the second year of treatment there is a higher yield under the nitro-chalk treatment than under the sulphate of ammonia treatment.

Discussion of results.

In the first year of treatment and particularly in the first two months, sulphate of ammonia was superior to nitro-chalk as regards total yield. In the second year, however, nitro-chalk proved to be far superior to sulphate of ammonia. Under the nitro-chalk treatment there was a reduction in the yield of *Molinia*, but this reduction was compensated for by a considerable increase in the yield of bent. In other words the original *Molinia* pasture was changed into a bent pasture, forming a dense sward. Under the sulphate of ammonia treatment there was a reduction in the yield of *Molinia*, but not to such a marked degree as under the nitro-chalk treatment. While a slight increase in fine-leaved fescue is recorded, bent shows no increase in yield under the sulphate of ammonia treatment. Thus it is seen that there has been comparatively little change in the composition of the original *Molinia* pasture under this treatment; the appearance of the pasture has also remained constant, being an open pasture with a large amount of bare ground. The implications of these results are of great importance when the length of the growing season is considered. *Molinia* as a grass has a very short growing season, which begins about the middle of May and ends towards the latter part of July or the early part of August. After this period no growth takes place and the herbage dies off. Bent, however, has a much longer growing period, as shown by the figures given in Tables I and II, and does not die off or burn to the same extent as *Molinia*. Also it is generally recognised that the palatability of the two species differs considerably. Bent, although not a highly palatable species when compared with the rye-grasses, is considerably more palatable than *Molinia*. Consequently, the transforming of a *Molinia* pasture into a bent pasture may be regarded as a considerable improvement. In order to bring about this improvement, judging from the results obtained in this experiment, nitro-chalk is to be preferred to sulphate of ammonia as a nitrogenous

fertilizer on *Molinia* pastures. It is to be particularly emphasised, moreover, that these results have been obtained under a system of rigid defoliation, and consequently under grazing conditions such rapid changes as have been brought about could only be effected by supporting the dressings of nitro-chalk with a system of controlled grazing of altogether greater intensity than that normally practised on open hill sheep walks. Further evidence is being obtained on the severally practical aspects of the ecological results that have been brought under review. Critical trials are also being set up to test the influence of a large number of nitrogenous fertilizers.

Summary.

(1) In the first year of treatment sulphate of ammonia appeared to be superior to nitro-chalk.

(2) By the second year the *Molinia* pasture was transformed into a bent pasture under the nitro-chalk treatment, while there was very little change in the flora under the sulphate of ammonia treatment.

(3) Nitro-chalk appears to be superior to sulphate of ammonia as a nitrogenous fertilizer on *Molinia* pastures.

Acknowledgment.

I desire to express my gratitude to Professor R. G. Stapledon, M.A., for his helpful interest and advice.

REFERENCE.

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THE DISTRIBUTION OF WILD WHITE CLOVER (*TRIFOLIUM REPENS*) IN RELATION TO THE ACTIVITY OF EARTHWORMS (*LUMBRICIDAE*).

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The incidence of earthworm (*Lumbricidae*) activity as evidenced by casts, with areas abundantly colonised by wild white clover (*Trefolium repens*) has long been recognised. Graziers regard the presence of worm casts as being in some way a factor operating to the benefit of *Trifolium repens*, and welcome the presence of casts.

The belief that casts may exert a stimulus upon *Trifolium repens* led to the construction of an implement on the principle of a Cambridge roller, each ring being surmounted by spikes. The action of this device was to throw up little mounds of earth resembling casts in appearance (1). The results of this treatment were insignificant.

It is hoped that the following notes may elucidate the relationship between the two organisms, and incidentally provide some information regarding the nature and composition of worm casts. It may further show to what extent worm casts or artificial "casts" are of value in relation to the mechanical improvement of grassland.

Distribution of Trifolium repens in Relation to Casts.

General observation over large areas of permanent grass land of different types leaves no doubt as to the incidence of worm casts with *Trifolium repens*, and shows that there is some correlation between the relative abundance of the two. It is also a matter of interest that in the Province of Ontario, Canada, where *Lumbricidae* do not occur, *Trifolium repens* is not a component on the herbage in the regions where *Lumbricidae* are absent (2).

Activity as manifested by casts, varies seasonally and periodically due to the physical condition of the earth with regard to moisture and temperature. At any given time, however, the difference in the number of casts on a given area of pasture on a tract of land, and the number of casts on another area of the same dimensions on the same tract of land, is a reliable measure of the comparative activity of *Lumbricidae* on these sites.

Abundance of casts is obviously a measure of earthworm activity, in the form of foraging and excavating, but the value of cast abundance as a measure of earthworm population has not been estimated. This latter point is not material to the problem under consideration.

To obtain data with regard to the relationship between the abundance of *Trifolium repens* and earthworm activity as manifested by casts, a survey was carried out on certain types of land in the county of Norfolk. The following method of survey was adopted :—

During the period January to May, 1932, three areas were chosen, Massingham Heath, overlying sand or chalk; Wooton Sand Pits, sandy heath; Gaywood River-side, alluvial soil.

The method of taking counts adopted in all cases, was to traverse the ground in various directions making random throws

with a metre quadrat. Readings were taken to ascertain the percentage area of the ground within each quadrat covered by *Trifolium repens*. At the same time the number of worm casts in the quadrat were counted.

The quadrat readings were arranged in groups, a, b, c, etc. (see Table I, column 1, below), according to the type of vegetation which characterised them. These quadrats which contained any proportion of *Trifolium repens* were placed in a separate group (see Group d, Table I, below) and subjected to more detailed analysis in a separate Table (see Table II, below). In the case of the latter group containing any proportion of *Trifolium repens* the casts were collected from each quadrat and weighed, the total weights of casts in each quadrat being recorded.

It was difficult in some cases to distinguish true worm casts from earth adhering to them at the base and for this reason only the definitely shaped portion of the cast was collected. In Group b, Table V, it was impossible to obtain accurate weighings of the worm casts, and for this reason no further tabulated examination was made of this group. Inaccurate weighings were due to wet adhering earth and the close proximity of the casts to one another.

The results obtained are set out in the following tables :—

TABLE I.

Massingham Heath. (200 Quadrats).

1	2	3	4	5	6	7
Group.	*No. of quadrats per group.*	*Vegetation type.*	*Per cent. area of T.R.*	*Casts per quadrat.*	*Av. No. of casts.*	***Total of casts.***
a	153	Erica ssp. Pteris. Agrostis. Festuca	0	0	-	0
b	19	,,	0	1-2	1.42	27
c	21	,,	Trace	1-4	2.80	59
d	7	Festuca, Agrostis Lolium Poa and T. Repens	2.5-8	10-36	26.00	182

TABLE II.

Detailed examination of Group d Table I above.

1	2	3	4	5	6
Quadrat.	*Vegetation other than T. repens.*	*Per cent. area covered by T. repens.*	*No. of casts.*	*Total Wt. (air dry) of casts.*	*Av. Wt. (air dry) of casts.*
1	Agrostis Festuca.	2.5	17	60.0 gms.	3.50 gms.
2	Agrostis Festuca.	4.0	10	27.0 gms.	2.70 gms.
3	Agrostis Festuca.	5.0	36	135.0 gms.	3.72 gms.
4	Agrostis Festuca.	5.5	27	81.0 gms.	4.20 gms.
5	Agrostis Lolium Poa.	5.5	31	120.0 gms.	3.87 gms.
6	Agrostis Lolium Poa.	6.0	29	108.0 gms.	3.72 gms.
7	Agrostis Lolium Poa.	8.0	32	105.0 gms.	3.27 gms.

TABLE III.

Wooton Sand Pits. (100 Quadrats).

1	2	3	4	5	6	7
Group.	*No. of quadrats per group.*	*Vegetation type.*	*Per cent. area of T.repens.*	*Casts per quadrats.*	*Average number of casts.*	***Total casts.***
a	33	Bare sand.	0	0	0	0
b	59	Erica ssp, Pteris,	0	0	0	0
c	2	*Blown sand	Trace	5.17	11.00	22.00
d	6	Agrostis Lolium, Poa and T.repens	3.30	20.72	32.33	193.98

* Remains of dead vegetation found at depth of about 10 cms.

TABLE IV.

Detailed examination of Group d Table III above.

1	2	3	4	5	6
Quadrat.	*Vegetation other than T.repens.*	*Per cent. area covered by T.repens.*	*No. of casts.*	*Total Wt. (air dry) of casts.*	*Av. Wt. (air dry) of casts.*
1	Agrostis Lolium Poa.	3.0	20	135 gms.	6.75
2	ditto.	5.5	27	126 gms.	4.66
3	ditto.	6.0	24	93 gms.	3.87
4	ditto.	8.0	31	165 gms.	5.32
5	ditto.	10.0	20	108 gms.	5.40
6	ditto.	33.0	72	300 gms.	4.16

TABLE V.

Riverside Pasture, Gaywood. (100 Quadrats).

1	2	3	4	5	6	7
Group.	*No. of quadrats per group.*	*Vegetation type.*	*Per cent. area of T.repens.*	*Casts per quadrat.*	*Av. No. of casts.*	*Total casts.*
a	7	Coarse patches of Dactylis, Agrostis, Holcus.	Trace	4-11	5.57	39
b	13	Lolium Poa, T.repens.	10-30	30.87	77.61	1,009

Tabless I, III, and V above show clearly that areas which exhibit worm casts coincide exactly with those containing in their vegetation a proportion of *Trifolium repens.*

There appears from an examination of Tables II and IV, columns 3, 4, and 5, to be some indication of correlation between the abundance of worm casts on a given area, and the proportion of ground covered by *Trifolium repens.* The tables as a whole give concrete evidence of a frequently recorded phenomenon.

The Nature of Worm Casts.

Before proceeding further with the investigations it was considered necessary to examine the nature of worm casts in comparison with the underlying soil.

Casts may be divided into two types, *i.e.*, the type formed from the top soil and vegetable matter drawn in from the surface, and the type produced when the earthworms are working in the subsoil. When the latter part of the earth is of lighter colour than the top soil the casts from this region may easily be distinguished by eye. Observation shows that taking the year throughout " subsoil casts " are comparatively insignificant in number. Their abundance varies periodically.

In the year 1929 a sample of " subsoil " casts was collected from Hardwick Park, Derbyshire. In this case the top soil overlay a light coloured sub-soil of Magnesium marl, and " subsoil " casts were easily distinguished.

The sample was submitted for analysis to Mr. H. T. Cranfield, Advisory Chemist, Midland Agricultural and Dairy College. The results are set out in Table VI, below. Compare with the results in Table VII, in which the samples resemble " topsoil " casts.

TABLE VI.

" Subsoil " Casts. (100 Casts per sample).

Sample.	*Description.*	*Lime requirement per cent. CaO.*	*Exchangeable CaO.*	*Nitrogen.*
1	Worm casts.	0.070	0.632	0.410
1a	Adjacent soil.	0.149	0.632	0.480

A further series of samples representing " topsoil " casts were taken in the county of Norfolk in the year 1931. The analyses were made by Mr. F. Hanley, Advisory Chemist, of the School of Agriculture, Cambridge (who carried out all subsequent analyses).

The results are given in Table VII, below.

It is seen from Table VII that where $CaCO_3$ is present in the soil, there is a still higher percentage present in the casts. In example 1 and 1a $CaCO_3$ is absent in the soil, there being an acid condition with a lime requirement of 0.104 per cent. CaO, but in the casts $CaCO_3$ is present to the extent of 0.82 per cent. In cases, *e.g.*, example 4 and 4a, where both soil and worm casts are acid, there is a lower lime requirement in the casts than in the soil.

In all cases in Table VII the exchangeable calcium is higher in the casts than in the soil. It is also noticeable in all examples in the above Table that there is a higher percentage of nitrogen in the casts than in the soil, which may be taken as expressing a

TABLE VII.

"Topsoil" Casts. (100 Casts per sample).

Sample.	*Description.*	*Presence of $CaCO_3$ per cent.*	*Exchange-able CaO per cent.*	*Lime require-ment per cent. CaO.*	*Total nitrogen.*
1 Casts	Massingham Heath Chalk	0.32	0.328	Nil.	0.368
1a Soil	Massingham Heath Chalk	Nil.	0.113	0.104	0.224
2 Casts	Gaywood Garden Soil ...	0.65	0.360	$CaCO_3$ present.	0.395
2a Soil	Gaywood Garden Soil ...	0.40	0.320	"	0.318
3 Casts	Wooton Sand Pits ...	4.70	0.259	"	0.220
3a Soil	Wooton Sand Pits ...	0.65	0.123	"	0.111
4 Casts	Massingham Heath Sand	Nil.	0.300	0.035	0.325
4a Soil	Massingham Heath Sand	Nil.	0.122	0.063	0.167
5 Casts	Massingham Heath Sand	*	0.484	Nil.	0.430
5a Soil	Massingham Heath Sand	*	0.368	Nil.	0.193

* Figures not determined.

higher content of organic matter. In the case of a "subsoil" cast (Table VI) the organic matter content will be lower than that of the soil, and consequently there is lower percentage of nitrogen in the cast than in the soil.

The higher nitrogen and organic matter content of the "top-soil" cast than that of the soil is explained by the well known habit of *Lumbricidae* in drawing in vegetable matter from the surface. During excavation at a lower level, as evidenced by a "subsoil" cast there is no ingestion of vegetable matter, and the

consequent lower nitrogen content is shown in the analysis of the cast.

The problem of the higher calcium carbonate content or lower lime requirement of the cast as compared with the soil is a somewhat complex one. Three explanations might be offered :—

(1) The presence of calciferous glands in *Lumbricidae,* these excrete or secrete calcium carbonate into the alimentary canal. Several theories exist as to their proper function (2).

(2) The subsoil may possess a higher calcium carbonate content than the topsoil or possess a lower lime requirement. This lower stratum may be exploited by *Lumbricidae.*

(3) The ingestion of organic or vegetable matter, from the soil surface, possessing a higher proportion of calcium compounds than the soil.

The existence of calciferous glands which might excrete calcium carbonate spasmodically, might explain the higher calcium carbonate content of some casts than of others on the same site. It does not explain the fact that all casts contain more calcium carbonate, or are of a lower lime requirement than the soil; for if the glands are responsible for this phenomenon they must be supplied from some source other than the topsoil.

That the casts contain a higher *total calcium* content than the soil was shown by the following investigation.

A sample of casts (about 200) were collected from a site on Massingham Heath, the soil was also sampled in the approved manner.

The result of the analysis was as follows :—

Casts	0.134 per cent.	Total CaO.
Top 12in. of Soil	0.077 per cent.	Total CaO.

As regards the subsoil being exploited as a source of calcium, this appears to be a possibility upon first consideration. An investigation showed that in a certain case where the soil and the worm casts both showed a lime requirement the soil possessed a higher requirement than the casts, but below a depth of 1 ft. the lime requirement diminished.

In the above case the casts were collected over an area of about 500 square yards (Massingham Heath, Norfolk). The soil was sampled throughout each foot to a depth of 7 ft. This sampling was facilitated by the fact that the area was being excavated for sand. The results are set out in Table VIII.

TABLE VIII.

Sample.	*Lime requirement at per cent. CaO.*
Casts	0.120
1 Ft. depth	0.154
2 Ft. depth	0.092
3 Ft. depth	0.067
4 Ft. depth	0.107 (Acid pan).
5 Ft. depth	0.044
6 Ft. depth	0.053
7 Ft. depth	0.044

It would appear from the above that the less acid soil of the casts might be obtained from the subsoil. The casts were, however, definitely of the " topsoil " type, being of the same colour as the soil. The latter, which was from 10in.-12in. deep, was of a greyish black colour, while the subsoil was a golden yellow sand : there was a sharp line of demarcation between the two.

It was revealed further upon analysis that the respective nitrogen contents were as follows :—

" Casts "	0.258 per cent. Nitrogen.
Soil to 12in.	0.125 per cent. Nitrogen.

It is obvious that if *Lumbricidae* were exploiting the subsoil the organic matter and nitrogen content of the casts would be lower than that of the soil. As in all cases (excepting Table I, where " subsoil " casts are represented) the nitrogen content of the casts is higher than that of the soil, it is reasonable to assume that " topsoil " casts are composed to a certain degree of vegetable matter drawn from the surface of the soil. It is, therefore, apparent that this material is the source of the calcium which goes to raise the proportion in the cast above that in the soil.

In the above connection it is interesting to note that Darwin suggests that the calciferous glands may function to eliminate calcium obtained from the dead vegetation which earthworms devour (8).

It is seen that worm casts are of two types, *i.e.*, " topsoil " and " subsoil ". The relative abundance of the latter appears to show seasonal variation probably coinciding with periods when excavation is taking place due to changes in temperature or moisture content of the soil.

All casts appear to show a higher calcium carbonate content, or lower degree of acidity as expressed by lime requirement, than the soil.

In the case of a " subsoil " cast there is a lower nitrogen content than that of the soil, but in a " topsoil " cast the nitrogen content is higher than that of the soil.

As " subsoil " casts are greatly in the minority, it may be stated that an accumulation of worm casts in the soil surface provides a superficial layer or " mulch " of soil of higher calcium carbonate content, or lower lime requirement and higher nitrogen and organic matter content than the rest of the soil.

The rate of accumulation of casts varies in direct proportion to the activity of *Lumbricidae*, but there is every reason to believe that the figure given by Darwin, *i.e.*, 0.2in. per annum, is a fair average (4).

The Relation between Trifolium repens and Lumbricidae.

It has been shown that colonies of *Trifolium repens* coincide with the presence of worm casts and that the abundance of *Trifolium repens* appears to be directly correlated with earthworm activity.

Analysis has revealed that worm casts possess points of difference to the underlying soil in respect of calcium carbonate or lime requirement, and nitrogen or organic matter content.

In considering factors which may be responsible for the relationship between the two organisms a number of possibilities arise and these are dealt with in turn.

The Influence of Casts.

A surface covering of casts provides a mulch of soil differing from that of the underlying soil in respects already dealt with, and this on first consideration might be of some significance.

Pot experiments conducted by the writer showed that *Trifolium repens* germinated better in a medium of casts than in one of the underlying soil, but later the plants tended to develop a superficial root system and in consequence suffered more from drought than those grown in the underlying soil.

Further tests showed that Agrostis, the chief competitor of *Trifolium repens*, also germinated more vigorously in a medium of casts than in the underlying soil. It has been clearly shown that Agrostis benefits by a superficial neutral medium for germination (5). It would therefore appear that as far as germination and establishment are concerned a medium of casts confers no more benefit upon *Trifolium repens* than upon its competitors.

On the other hand a large and denuded cast provides a bare and unshaded area of ground which appears to exert an attraction to runners of *Trifolium repens* when growing in a dense sward. It may be noted occasionally that a runner will establish a shoot upon such a site and give rise to a plant possessed of larger leaves than those competing with a dense population of grasses.

The above phenomenon may be of some significance, but cannot be of primary importance, for if this was the case the appearance of worm casts on a newly made lawn, or a putting green produced by close mowing of the existing turf, would precede the proliferation of *Trifolium repens*, but the two phenomena appear to materialise at the same time.

It was further noted that where large numbers of small heaps of earth, resembling worm casts in configuration, were produced by a machine, that no significant increase in the abundance of *Trifolium repens* was evident (1).

Trifolium repens as a Food Supply for Lumbricidae.

The possibility of *Trifolium repens* proving an attraction to *Lumbricidae* by providing a supply of food must be considered.

In cases where *Trifolium repens* was grown in pure culture (for educational or experimental purposes) counts were taken. (Oxburgh, Norfolk, and Chesterfield, Derbyshire). It was found that there was no greater number of casts per square metre upon the clover plots than upon the surrounding bare earth or upon plots occupied by certain other species. It was found, however, that there appeared to be fewer casts upon plots of *Agrostis stolonifera* and *Festuca ovina* where a mat of surface roots had formed.

When lawn mowings are drawn into the burrows of earthworms, no preference appears to be shown for clover leaves.

Soil Acidity and Neutrality.

It has been observed that worm casts are scarce on acid patches in a field and comparatively abundant on neutral areas (6).

It has been suggested in this connection that the presence of calcium carbonate in the soil is essential for the functioning of the calciferous glands. On the other hand it is not certain that the glands are not merely excretory (7) (8). Again it has been shown that calcium is obtained from compounds existing in overlying vegetation ingested by *Lumbricidae*.

While the preference to *Lumbricidae* for neutral areas of soil rather than acid soil is very evident, it must be borne in mind that these observations have been conducted upon pastures, where the neutral patches are also the most closely grazed, being selected by livestock.

It has been noted that even on an acid soil worm casts will appear as a result of close mowing of the turf in the case of a lawn, putting green, or bowling green, and that their number will tend to increase with time.

Observations were carried out upon Massingham Heath, Norfolk, on a turf dominated by *Agrostis* and *Festuca*. In this case the soil was acid in reaction (pH5 approx.), and with an estimated lime requirement of 0.068 per cent. CaO, a careful search failed to reveal more than 8.8 casts per sq. metre, on an average.

On the same site areas of varying dimensions were bared, by turf being removed for lawn making. Upon these bare areas casts began to appear in increasing numbers until up to the end of twelve weeks, when they averaged 22.7 per sq. metre.

While the casts were increasing upon these areas, it was noted that isolated plants of *Trifolium repens* (springing from old rootstocks) proliferated rapidly upon the bare soil. A fringe of *Trifolium repens* appeared round the margin of the bare areas; this fringe was formed from runners of plants existing in the turf and apparently attracted towards the light.

Considering the influence of calcium carbonate content or lime requirement of the soil in relation to *Trifolium repens* one notes that in a grazed pasture, colonies of *Trifolium repens* coincide with patches of soil possessing the highest calcium carbonate content or lowest lime requirement.

On the other hand a case came to the notice of the writer where, in a new pasture, the colonies of *Trifolium repens* actually coincided with the acid patches in the field. The seed mixture which contained *Trifolium repens* had been sown down under barley, and the barley had failed upon the acid patches. Prior to the barley a crop of swedes had been badly affected with anbury (*Plasmodiophora brassica*) upon these patches. It would appear that the admission of light, by the failure of the barley, had been a more potent factor than soil acidity.

The toleration of intense acidity by *Trifolium repens* is now a well established fact (9). The species will grow abundantly on an acid soil if light restriction is removed, *e.g.*, by close mowing or treading. Where, on the other hand, *Trifolium repens* coincides with the neutral patches of soil in an established pasture, as already instanced, it must be noted that these patches are most closely grazed by stock and overshading influences are removed.

Abundant evidence of the reaction of *Trifolium repens* to light may be gathered by observation upon footpaths, grass verges at roadsides, banks and similar sites.

Lumbricidae and Soil Moisture.

It has been shown by abundant research and observation that *Lumbricidae* are intolerant of a dry condition of the soil,

and upon this state prevailing will aestivate in specially constructed chambers in the soil (10).

It is obvious that areas dominated by *Trifolium repens* will admit moisture more freely to the soil than when the dominant herbage is *Agrostis* spp., *Festuca* or *Holcus* spp., all mat-forming plants. Close mowing or grazing will, by defoliation of the herbage, reduce losses of moisture by transpiration and by restriction of root range.

The activity of *Lumbricidae* as evidenced by casts, is to be observed upon bare areas in a field, in the region of gateways, and upon footpaths. Mention has already been made of the increase of casts upon areas from which turf has been removed.

Conclusions.

From a consideration of the foregoing examination of all relevant factors it would appear that the incidence of worm casts with areas colonised by *Trifolium repens* is not directly due to the influence of *Lumbricidae* or their casts upon the proliferation of *Trifolium repens*, nor are *Lumbricidae* directly attracted by *Trifolium repens*.

Both organisms appear to be favoured by the biotic factor as manifested by close grazing or mowing. In the case of *Trifolium repens* the admission of light appears to be the most potent influence, while in the case of *Lumbricidae* it is most possibly the more easy access and better supply of moisture.

It will be seen that attempts to stimulate the proliferation of *Trifolium repens* by the creation of artificial " casts " is futile.

Incidentally it is shown that worm casts create a surface layer or mulch of earth with a higher calcium carbonate content or lower lime requirement, and at the same time a higher nitrogen or organic matter content, than the under-lying soil.

In the case of lawns, greens and other closely mown areas the proliferation of *Trifolium repens* and the presence of worm casts appear to be an unavoidable accompaniment of the practice of close mowing, unless checked by chemical agents.

Acknowledgments.

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THE VALUE OF FIELD TRIALS WITH SWEDES.

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Introduction.

The inconclusive results obtained after many years of field trials with swedes, both in respect of manurial requirements and the comparative value of popular varieties, call for a re-examination of the object in view in laying down trials and of the technique employed. It is evident that trials have often been vitiated by the occurrence of diseases and the writer therefore undertook to make an attempt to throw some light on the matter. Before the importance of diseases can be assessed it is clear that the variability in cropping power apart from disease incidence must be ascertained. That this cannot be ignored is seen from a trial carried out on the College Farm in 1925. The object was to test the relative cropping power of the varieties Magnificent and Superlative against that of Up-to-Date. In each case five replications of unit plots consisting of two drills of each variety alternated with each other; the results being tabulated in Table I.

The difference in the mean yields of the first two varieties is 28 cwt. per acre, but this is exposed to an error of 26 cwt. (5.38 per cent.), and no particular significance can be attached to it. It is equally true of the second comparison, where the difference of 12 cwt. has a p.e. of 9.8 cwt. (2 per cent.). The fact that these differences are not significant is of less interest than

TABLE I.

Swede Trial on College Farm, Aber, 1925. (**Yields in cwt. per acre**).

	Up-to-Date.	*Magnificent.*	*Up-to-Date.*	*Superlative.*
	cwt.	cwt.	cwt.	cwt.
	381	540	480	480
	487	517	450	480
	547	404	487	494
	432	496	501	473
	496	502	487	540
Mean	469 ± 21 cwt. (1.4 per cent.)	492 ± 15.5 cwt. (3.1 per cent.)	481 ± 5.6 cwt. (1.2 per cent.)	493 ± 2.1 cwt.) (1.6 per cent.)

the great variability in the yields from the different replications of the first trial as compared with those found in the second and adjacent trial. Although the two comparisons with the variety Up-to-Date were laid down under apparently identical conditions the variability of the first one was such that a difference of 78 cwt. per acre in the average yields of the plots would have been necessary before definite conclusions could be drawn, whereas in the second trial a difference of only 30 cwt. per acre would have been sufficient. In the light of the more detailed trials carried out in 1932 and reported on below, it is unnecessary to speculate on the causes of these irregularities in yield beyond saying that diseases were certainly not to be held accountable.

Variability within an apparently uniform crop of one variety.

In practice, the estimation of the yield of a crop is a matter of sampling, and the magnitude of the probable error is nothing more than a measurement of the accuracy with which fair samples have been taken. As a preliminary to the investigation, therefore, we must have some idea of the degree, and causes (apart from diseases) of the variation in yield within an apparently uniform crop of a single variety. Similar determinations have been made in other areas with cereals and mangolds, but these cannot be used without checking under North Wales conditions,

so that a very uniform swede crop of the variety Wilhelmsburger, growing on the College Farm, Aber, was selected for this purpose in 1932. The crop was on land sloping down from south to north and had the drills running in the same direction. Sixteen of these drills were divided accurately into 80 unit plots, each one drill wide and 20 yards long (1/312 acre) and these units were lifted, cleaned, and weighed separately. Table II gives the yields obtained from each unit plot in the position it occupied in the field. The total number of roots per unit length of 20 yards is also given in brackets, together with the number discarded as being in an advanced stage of decay owing to dry-rot or bacterial rot. Finger and toe was practically absent, not more than half a dozen roots showing the merest trace of the disease, whilst the Table shows that only a trivial number were discarded for other causes. Mildew was evident on all the plants but, judging from the yield obtained, the disease had not appreciably affected the crop; in any case there was no reason to suppose that its effects were not uniformly distributed over the unit plots so as to affect the experimental error.

TABLE II.

Yields, in lb., of Unit Plots of the variety Wilhelmsburger.

EAST

Row.	*Belt 1.*	*Belt 2.*	*Belt 3.*	*Belt 4.*	*Belt 5.*
1	210(54)—0	209(59)—0	207(51)—0	221(62)—0	208(62)—0
2	198(62)—0	184(66)—0	210(65)—0	215(65)—0	198(56)—0
3	188(63)—0	196(56)—0	213(56)—0	187(56)—6	202(58)—0
4	201(77)—0	208(77)—0	213(77)—0	216(73)—3	222(77)—0
5	177(57)—0	192(56)—0	199(58)—0	205(53)—2	187(52)—0
6	202(60)—0	224(62)—0	208(57)—0	245(67)—0	217(61)—0
7	135(38)—0	167(41)—0	194(44)—0	172(45)—0	187(50)—0
8	189(51)—0	231(55)—0	226(59)—0	217(58)—0	211(49)—0
9	197(64)—0	221(62)—0	204(69)—0	214(65)—0	195(68)—0
10	194(64)—0	211(56)—0	205(51)—0	211(60)—0	206(57)—0
11	175(71)—0	221(69)—0	221(70)—0	222(74)—0	212(71)—0
12	180(57)—0	213(58)—1	203(55)—0	190(53)—0	198(49)—0
13	204(61)—0	215(62)—0	210(57)—0	226(56)—0	197(61)—0
14	152(46)—1	177(46)—0	188(54)—0	182(56)—0	158(57)—0
15	220(52)—0	216(55)—1	196(52)—0	219(60)—0	211(55)—0
16	188(55)—0	201(52)—0	203(53)—0	202(52)—0	190(50)—0

WEST.

Note.—For each unit plot one drill wide and 20 yards long (1/312 acre) the yield (in lb.) is first given, then the number (in brackets) of roots present, and finally the number rotten and unfit to weigh, to be subtracted from the number present.

The variations in yield approximate to a normal frequency curve so that one is justified in averaging the results. A rough guide to the changes in fertility of the trial ground can be found

by adding the weights of the unit plots across the drills from east to west and then along the drills from south to north as in Table III.

It is evident that the soil becomes more fertile as one passes from south to north along the drills until the fifth set of 20 yard lengths of drills is reached, when the fertility again falls off. On the other hand there is no evidence of any drift in fertility from east to west across the drills, notwithstanding the marked fall in the yield of some drills. The effect of such changes in soil

TABLE III.

Demonstrating changes in soil fertility.

A. Along the drills.		*B. Across the drills.*
South.		East.
	lb.	lb.
Belt 1.	3010	1055
Belt 2.	3286	1005
Belt 3.	3300	986
Belt 4.	3344	1060
Belt 5.	3199	960
North.		1096
		855
		1074
		1031
		1027
		1051
		984
		1052
		857
		1062
		984
		West.

fertility can be ascertained by treating Belts 1 and 2 as separate trials, each of four replications of four of the unit plots (*i.e.*, 1/78 acre) in each case. The average yield of each plot of this size in Belt 1 is 752 lb. $\pm$ 1.2 per cent., whilst in Belt 2 it is 821 lb. with the same p.e. The error of the difference (8.4 per cent.) between these two averages is only 1.7 per cent., so that entirely erroneous conclusions might have been drawn if two varieties had occupied the Belts or two treatments had been applied to the one variety. A similar illustration can be quoted from the result of a trial in 1923, in which the object was to test the effect of lime on oats and on the succeeding swede crop. Nine plots of swedes, each two drills wide and 76 1/3 yards long (1/44 acre) had received a dressing of 17 cwt. of ground lime per acre, and the average yield obtained was 1,503 lb. $\pm$ 0.9 per cent. Adjoining these plots were four similar ones which had

received 34 cwt. per acre and averaged 1,688 lb. ± 0.2 per cent., whilst beyond these were 25 unit plots receiving no lime which yielded an average of 1,680 lb. ± 0.7 per cent. By dividing the unlimed plots into two series of unit plots a significant difference was found between them, and it is evident that what had been measured was not the effect of lime but the variation in soil fertility, helped or retarded to an unknown extent by an application of lime.

Attention has already been drawn in Table III to the occurrence of very low-yielding drills. Reference to Table II also will show that all the low-yielding drills had less than the average number of roots per unit plot and that this is true whether the portion weighed occupied a fertile or infertile piece of land. This variation in the number of roots in the drill can be a serious source of error, as is evident if the yields of unit plots in two drills averaging 48 roots per unit length of 20 yards are compared with those from two drills with an average of 74 roots per unit length (*i.e.*, rows 7, 14 and 4, 11 respectively). With unit plots of 1/312 acre in size the average yield of the former was 171 lb. ± 2.2 per cent., and that of the latter was 211 lb. ± 1.4 per cent. The p.e. of the difference was 2.7 per cent., so that the observed difference of 19 per cent. cannot be due to chance.

In the present trial the most uniform yields, with the lowest p.e., would be obtained by taking the weights of crops only from Belts 3 and 4, since these occupy the most uniform piece of land. But this is only discoverable after *all* the unit plots have been weighed and is therefore useless as a general guide. The whole trial ground is probably fairly typical of the land available for county trials in this area, so that by calculating errors on the basis of the whole trial we shall approximate to the results to be expected from county experiments.

If the yields of all the eighty replications of the 1/182 acre unit plots are taken, the average yield per plot is found to be 202 lb., the probable error of any one plot being 12.2 lb. or 6.04 per cent. This experimental error decreases as the size of the unit plot increases up to about 1/40 of an acre, owing to the large variations caused by soil changes, etc., so that a relatively large plot is more likely to represent a fair sample of the whole trial ground than is a small plot; these changes in the p.e. of a single plot are shown in graphic form in Fig. 1. It will be seen that an increase in size of plot obtained by increase in length only is far less accurate than an increase in width across the drills. but that the most reliable results are obtained by increasing both length and width. This is not necessarly of general application,

for it is due in the present trial to the causes of variation operating both along the drills (*i.e.*, change of fertility) and across the drills (*i.e.*, variation in the number of roots per drill).

The suitability of any particular size of unit plot depends upon various practical considerations of which the most important are the area of land available for the trial, and the degree of accuracy required; the latter being itself dependent on the number of replications of the unit plots. The method by which any desired precision may be obtained has been described by other writers, but a brief explanation may conveniently be given here. The object of a field trial is usually to compare the average yields obtained from two or more treatments or from different varieties. It is generally agreed that if the two averages differ by more than three times the probable error to which the averages are exposed, one can accept this difference as a real one. A precision of 10 per cent. therefore means that the p.e. of the observed difference in mean yields must not be more than $\frac{10}{3}$ or 3.3 per cent., so that on a basis of a 25 ton per acre crop the difference would have to be at least 2.5 tons per acre before any significance could be attached to it. Similarly the p.e. for a 4 per cent. degree of precision (*i.e.*, 1 ton per acre) would be $\frac{4}{3} = 1.3$ per cent., whilst if the precision were increased to 2 per cent. the maximum p.e. permissable would be 0.67 per cent. and a difference of only 10 cwt. per acre in the average yields of the plots would be sufficient for an assurance that the result was not an accidental one. Now the number of replications required to give any desired degree of precision is found by dividing the square of the p.e. of one result by the square of the p.e. of the mean. We have already seen what is the maximum p.e. permissable for various degrees of precision, so that it is only necessary to substitute these values in order to obtain the number of replications required. For example, the p.e. of one plot measuring 1/312 acre was found in the present experiment to be 6.04 per cent., so that the number of replications required to give 10 per cent. precision would be $\frac{6.04^2}{3.3^2} = 4$ plots. Similarly if a difference of one ton in the mean yields, i.e., 4 per cent., was required to be significant the number of plots of this size would be $\frac{6.04^2}{1.3^2}$ or 22; whilst 82 unit plots would be necessary if we wish to base any conclusions on a difference of half a ton, *i.e.*, 2 per cent. in the mean yields per acre. In the same way we find that with unit plots

of 1/78 acre each we should require one, six, and twenty-three plots to ensure precisions of 10 per cent., 4 per cent. and 2 per cent. respectively. With either 1/39 or 1/19.5 acre plots the number required would be one, four and twelve. We are not yet in a position, however, to decide finally on either the size of unit

TABLE IV.

Variety Yield Trial with Swedes and one Turnip. 1932. Yields (in lb.) of Unit Plots of 1/312 acre each.

Variety.	*Drill.*	*Belt 1.*	*Belt 2.*	*Belt 3.*	*Belt 4.*	*Belt 5.*	*a.*	*b.*
Superlative ...	36	204(80)—0	173(68)—0	178(56)—0	187(60)—0	171(62)—0	73	65
do. ...	35	180(47)—0	189(57)—0	173(56)—7	207(62)—0	198(67)—0	50	58
Bruce ...	34	172(47)—1	166(57)—0	153(59)—8	176(54)—7	193(58)—0	57	55
do. ...	33	142(58)—2	134(66)—5	161(78)—4	177(79)—2	190(79)—1	63	72
Wilhelmsburger	32	211(62)—0	214(59)—0	216(51)—0	216(58)—0	225(55)—0	60	57
do. ...	31	203(63)—0	206(56)—0	228(54)—0	209(65)—0	215(61)—0	57	60
Bruce ...	30	146(60)—1	142(60)—8	176(53)—3	169(55)—6	182(57)—3	50	57
do. ...	29	144(63)—3	143(66)—4	169(61)—3	179(64)—4	169(67)—3	60	64
Wilhelmsburger	28	206(61)—0	198(65)—0	199(56)—1	206(63)—0	195(69)—0	60	63
do. ...	27	216(75)—0	210(81)—0	219(82)—0	217(83)—0	198(89)—4	78	82
Superlative ...	26	198(59)—0	214(57)—0	205(58)—0	211(52)—0	202(59)—0	57	57
do. ...	25	227(61)—0	234(68)—1	225(59)—1	223(63)—0	241(65)—0	60	63
Wilhelmsburger	24	200(58)—0	213(62)—0	220(60)—0	218(62)—0	217(65)—0	53	61
do. ...	23	181(75)—0	194(71)—0	202(72)—0	213(68)—0	185(68)—1	60	71
Bruce ...	22	184(73)—2	167(64)—5	199(53)—3	198(54)—5	158(59)—1	67	61
do. ...	21	153(53)—1	161(47)—2	147(49)—4	179(50)—5	153(81)—1	57	56
Superlative ...	20	213(63)—2	216(59)—0	196(55)—1	228(59)—0	193(59)—2	60	59
do. ...	19	178(47)—0	192(55)—0	188(58)—7	226(51)—0	210(73)—0	53	57
do. ...	18	215(71)—0	210(68)—0	210(50)—1	227(53)—0	221(55)—0	57	59
do. ...	17	202(59)—0	208(59)—0	235(56)—0	233(56)—0	188(61)—1	57	58
Wilhelmsburger	16	222(78)—0	231(86)—0	239(79)—0	241(86)—0	200(71)—0	73	80
do. ...	15	189(52)—0	190(52)—0	192(50)—0	190(51)—0	190(74)—0	60	56
Bruce ...	14	171(56)—1	149(56)—8	177(56)—3	160(64)—1	143(50)—5	53	57
do. ...	13	188(45)—1	140(42)—1	116(48)—2	131(52)—6	133(57)—6	40	49
do. ...	12	162(60)—1	182(57)—5	165(59)—4	162(54)—4	160(56)—4	57	57
do. ...	11	158(70)—4	176(77)—3	184(76)—1	161(78)—6	171(71)—5	63	74
Superlative ...	10	204(52)—1	205(50)—0	225(53)—0	182(55)—1	204(62)—0	53	54
do. ...	9	220(59)—0	207(56)—0	217(57)—0	222(60)—1	202(57)—0	57	58
Wilhelmsburger	8	219(57)—0	222(55)—0	214(53)—0	218(55)—0	216(54)—0	53	55
do. ...	7	231(51)—0	241(59)—0	248(57)—0	251(58)—0	231(55)—0	50	56
do. ...	6	228(62)—0	200(54)—0	202(56)—1	210(64)—0	202(58)—0	53	59
do. ...	5	206(54)—0	207(57)—0	215(59)—0	213(57)—1	192(56)—0	57	57
Superlative ...	4	220(78)—1	221(79)—0	205(69)—0	206(79)—1	218(75)—0	70	72
do. ...	3	209(51)—0	204(59)—1	210(57)—0	203(53)—0	194(58)—2	50	56
Bruce ...	2	118(50)—4	140(50)—8	180(52)—1	148(49)—7	148(57)—6	50	52
do. ...	1	101(36)—3	122(42)—2	116(38)—4	184(57)—3	153(59)—4	43	46

WEST. *Notes.*—*a* = Average number of plants per 20 yards, immediately after thinning.
b = Average Number of plants per 20 yards when lifted.

plot or the number most suitable for field trials, for the calculations so far have been based on the variation within an apparently uniform crop of one variety. It is necessary to see to what extent these figures apply when several varieties are under trial.

Varietal Yield Trial.

For this purpose the ground immediately adjoining the one described with the variety Wilhelmsburger was laid out as a comparative yield trial of the two swede varieties Wilhelmsburger and Superlative, and the yellow turnip " Bruce ". Twelve drills of each variety were arranged as shown in Table IV, so as to alter the position of each variety relative to the others as often as possible. The same Table also gives the yields, in pounds, of each of the sixty replications of 1/312 acre plots into which the twelve drills were divided, as well as the number of roots per unit plot and the number discarded as badly affected with dry-rot or bacterial rot.

As with the previous trial, the variation follows a normal frequency curve, and when the data are arranged as in Table III the same conclusions are to be drawn as to changes in soil fertility. In comparing the yield of Wilhelmsburger with that of each of the other varieties the method already explained can be followed, except that we are now dealing with two averages exposed to different experimental errors. The p.e. of these errors must therefore be found by the formula

p.e. of difference of means $= \pm \sqrt{a^2 + b^2}$, where a and b are the probable errors of the two means respectively. For significance, the difference in the two mean yields must be at least three times this new probable error. It will be observed from Fig. 2 that the curves illustrating the change in the p.e. of single plots of each variety according to the size of unit plots are of the same type as in Fig. 1. As in the previous trial, there is little advantage to be gained by increasing the size beyond 1/78 acre so far as the two swede varieties are concerned, but the turnip is exceptional both as regards the magnitude of the p.e. and the rate at which it falls with increase of size of plot. A comparison of the actual yields obtained is shown in Table V, from which it is clear that the two swede varieties are of equal cropping power and that either is much superior to the turnip.

The same conclusions are arrived at whatever the size of unit plot or number of replications, so it may appear that no direct help in settling either question is afforded by the trial. Indirectly, however, it serves to clarify the position considerably. In the first place it will be noted that the p.e. of the *mean* increases with increase in size of unit plot, in contradistinction to the p.e. of a single plot. This is, of course, due to the fact that the p.e. of the mean is arrived at by dividing the p.e. of a single result by the square root of the number of plots; so that

the large number of replications of the small plots gives a large divisor. With the same number of replications it is still true that plots of 1/78 or 1/40 acre each are more accurate than smaller

TABLE V.

Yield of Wilhelmsburger compared with Superlative and Bruce.

1 *Size of unit plot.*	2 *Wilhelmsburger. Yield (lb.).*	3 *Superlative. Yield (lb.).*	4 *p.e. differ. of 2–3.*	5 *Difference and if significant.*	6 *Bruce. Yield (lb.).*	7 *p.e. differ. of 2–6.*	*Difference and if significant.*
1/312 acre.	212 ± 0.62%	207 ± 0.7 %	± 0.93%	2.3% No.	158 ± 1.2 %	± 1.35%	25.4% Yes.
1/156 acre.	423 ± 0.6 %	414 ± 0.78%	± 0.98%	2.1% No.	317 ± 1.37%	± 1.49%	25.0% Yes.
1/78 acre.	852 ± 0.86%	830 ± 0.89%	± 1.24%	2.6% No.	630 ± 2.06%	± 2.23%	26.2% Yes.
1/39 acre.	1705 ± 1.13%	1661 ± 1.5 %	± 1.88%	2.6% No.	1260 ± 2.32%	± 2.58%	26.1% Yes.

plots, under the conditions obtaining in this trial. A more serious consideration brought out is the fact that the accuracy obtained with any particular number of replications is definitely less when one is comparing the yields of two varieties than when only one variety is concerned. The two varieties will react

Changes in p.e. in an apparently uniform crop of the variety Wilhelmsburger, according to the size of unit plot.

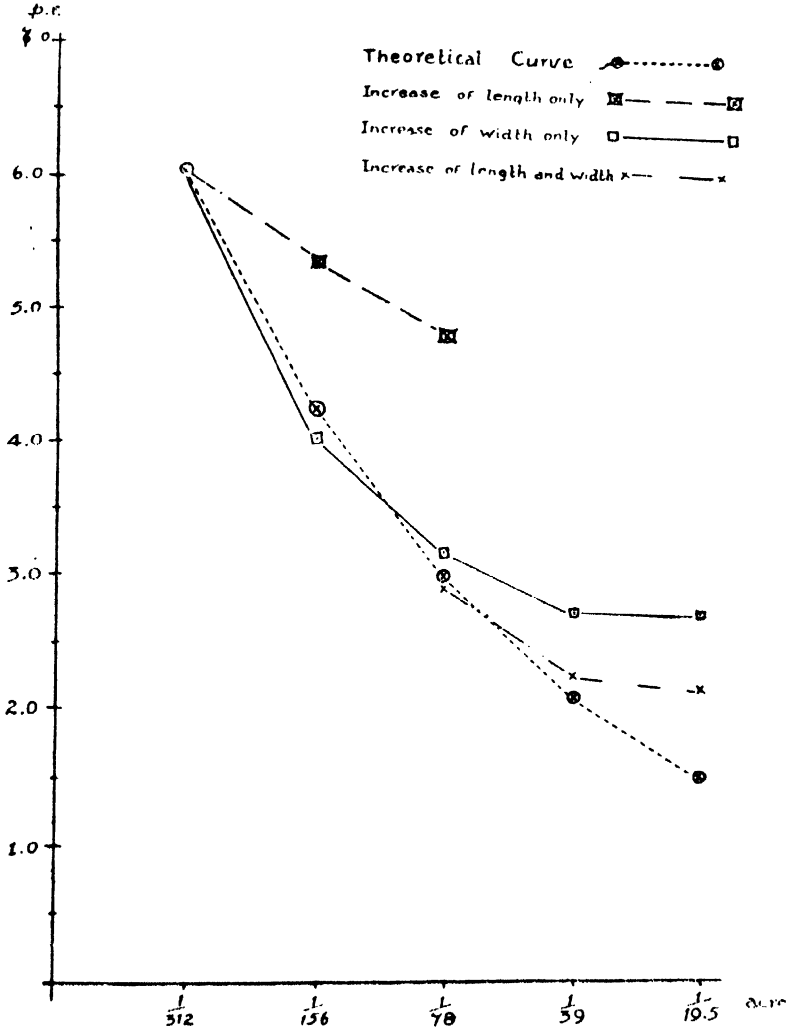

FIG. 1.

differently and irregularly to the climatic, cultural or other con ditions to which they are exposed, so that the p.e. is affected and, with it, the degree of precision to be expected from a specified number of plots. For instance, sixty replications of 1/312

VARIETY TRIAL.

Change in p.e. with size of unit plot.

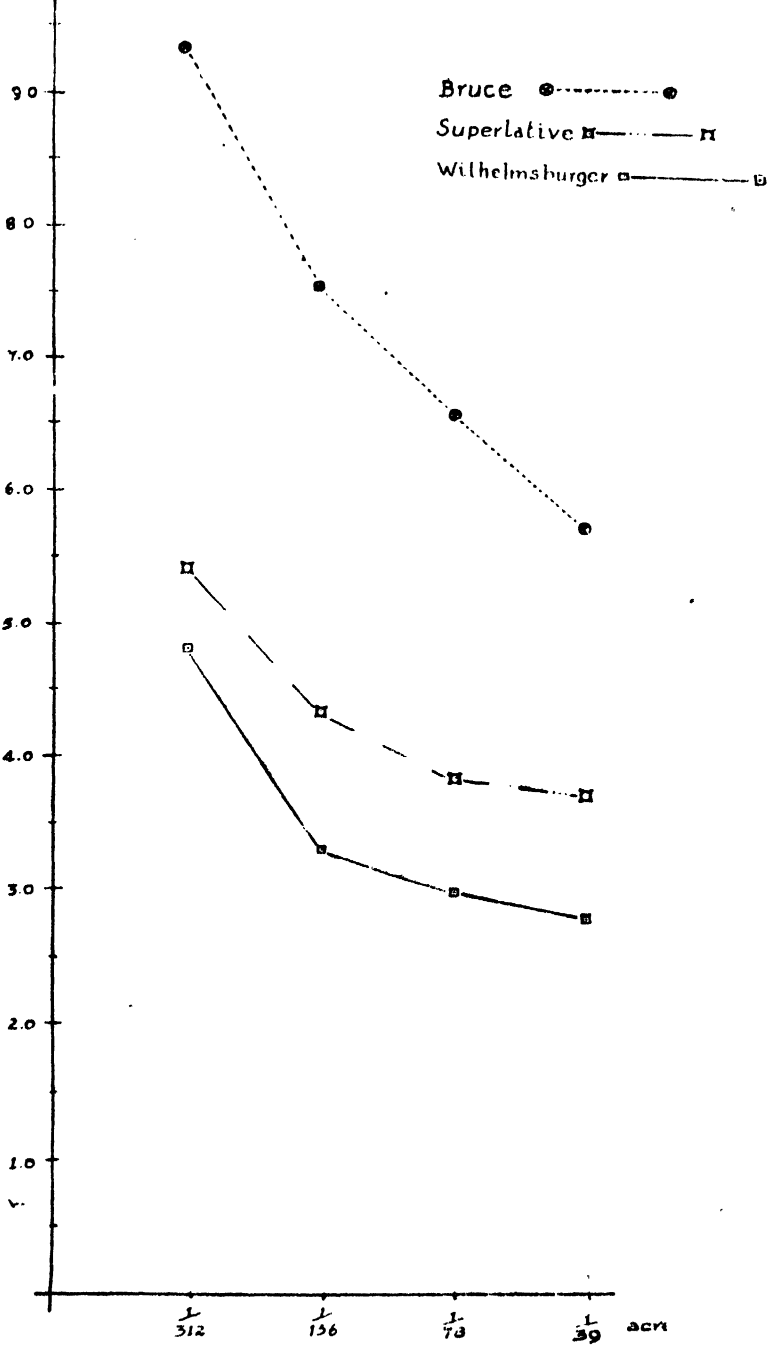

FIG. 2.

acre plots gave us a precision of 3 per cent. when Wilhelmsburger was compared with Superlative, but only 4 per cent. when compared with Bruce owing to the high p.e. of the latter plots (*cf.* Table V), whilst within the one variety (Wilhelmsburger) only 37 and 22 unit plots of this size would have been required for 3 per cent. and 4 per cent. precision respectively. Similarly, six Wilhelmsburger plots of 1/39 acre each gave a precision of 6 per cent. when compared with Superlative, but only 8 per cent. with Bruce, a degree of precision which would have been achieved by using only two and one plots respectively had Wilhelmsburger alone been under trial. Evidently it is of little use to plan a comparative trial of varieties or treatments without taking into account the possible causes of irregularity in yield from plot to plot.

The Causes of Variation in Yield.

The factors which induce variation in yield would seem to fall into two categories according to whether or not they are susceptible of control by the experimenter. Amongst those which could be eliminated or distributed over all the plots by careful planning would come (1) changes in soil fertility, (2) interference between varieties or treatments under trial, (3) irregular delivery of seed from the two sides of the drilling machine (4) irregularity in seeding according to whether the machine is sowing with a slope or against it, and (5) variations due to differences in spacing when the seedlings are thinned.

On the other hand, the magnitude and direction of other causes of variation in yield could not be foreseen; such are (1) the incidences of diseases like finger and toe, dry-rot, mildew, or bacterial rots, (2) pests such as rabbits, birds and swede midge or flea-beetle, (3) the residual effects of past manuring or the effects of abnormal weather might also operate in much the same way, *e.g.*, a water-logged condition of the trial ground might increase the variability of both varieties, and of one more than the other.

A. Controllable Factors influencing Variability.

(1) Soil changes must be anticipated, and in all probability the variation will not be a small one. The trial should be so arranged that the drills run with the main drift in fertility; any lateral change in fertility being minimised by using narrow plots and a sufficiency of replications. Plots two rows wide would best satisfy these conditions unless interference between varieties was to be expected. (2) Ordinarily a strong-topped, rapidly maturing

It is all the more necessary to maintain the minimum standard of accuracy suggested since unforeseen disturbing factors, such as disease, are the rule rather than the exception in swede trials, and as a result the precision obtained will be less than was expected. In the trial between Wilhelmsburger and the yellow turnip "Bruce", for example, the six replications of 1/39 acre plots gave a precision of only 8 per cent. (*i.e.*, a difference of 2 tons per acre was required on the basis of a 25 ton crop), and this was due in the main to an exceptionally severe attack of bacterial root-rot in the turnip. Variety trials must often have given inconclusive results owing to the prevalence of Finger and Toe at some centres and its absence at others. Indeed, this disease is so frequently the limiting factor in swede cultivation that resistance to attack should be determined before any variety is tried out for cropping power, on uncontaminated and on contaminated land. Unfortunately, only a very few varieties have been proved to exhibit any marked resistance to Finger and Toe. Of these, the best in the writer's opinion is Wilhelmsburger, which has also been shown in the present work to crop at least as well as the variety Superlative on land free from the disease, whilst on contaminated land its superiority is beyond question. These resistant varieties have been produced by selection from varieties showing no particular resistance, and there seems to be no reason why similar results could not be obtained from other varieties if the demand for them were sufficiently strong. The creation of such a demand is in the hands of the educational staffs of the counties and Colleges.

Apart from disease, it is questionable whether variety trials, as such, are of much practical utility at present. Varietal characters in swedes are not fixed to the extent they are in potatoes, and the variation within a variety as well as the synonymity known to exist, tend to restrict the general application of results which may be justified in a particular set of trials. The selection of a strain for disease resistance will tend to reduce these anomalies, since insufficient care in preventing cross-fertilisation, or the mis-use of a name would usually be detected on noting the reaction of the strain when exposed to infection. Again, a study of the results of variety trials over a number of years forces one to believe that the disturbing factors discussed in this paper exert much more influence on cropping power than any varietal difference. It is suggested, therefore, that for the present, attention in swede trials should be concentrated on such problems as (1) disease resistance, (2) reaction of different varieties to widely varying types of soil, (3) manurial requirements of

swedes, (4) effect of varying the distance to which seedlings are spaced, and (5) the keeping and feeding qualities of different varieties. Some of these problems are best tested with one variety alone, others would involve the use of different varieties, but it is suggested that in such cases widely differing *types* should be experimented with. The ultimate object should be the accumulation of data which would justify the segregation of types into classes according to their respective value to the farmer, *e.g.*, disease resisting; heavy or light land types, early or late maturing sorts and varieties possessing high keeping and/or feeding qualities.

The writer wishes to acknowledge his indebtedness to Professor R. G. White for valuable criticism; to Mr. E. J. Roberts for access to data relating to previous trials with swedes on the College Farm, and to the Laboratory Assistant, Mr. G. L. Turner, for unstinted help throughout the work. To Mr. Haydn Williams the writer is indebted for assistance in raising and weighing the crops.

Summary.

(1) The objects in view and the technique employed in laying down field trials with swedes are re-examined in regard to (*a*) the variation of yield of an apparently uniform crop of one variety in the absence of disease; and (*b*) the change in the probable error as the size and shape of the unit plots are altered.

(2) The extent to which the conclusions drawn from one variety are applicable to a trial of several varieties (or treatments) is examined in the case of a trial with two varieties of swede and one yellow turnip variety. It is shown that the swede varieties Wilhelmsburger and Superlative are equal in cropping power on land free from Finger and Toe, but that the turnip "Bruce" is definitely inferior to either.

(3) The causes of variation in the cropping power of swedes are discussed, and suggestions are offered for reducing them as far as possible.

(4) The conclusion is reached that swede variety trials, as such, are of little practical utility at present, and various alternative problems are suggested on which further information is highly desirable.

BACTERIOLOGICAL EXAMINATION OF MILK FROM WELSH COUNTY CLEAN MILK COMPETITIONS.

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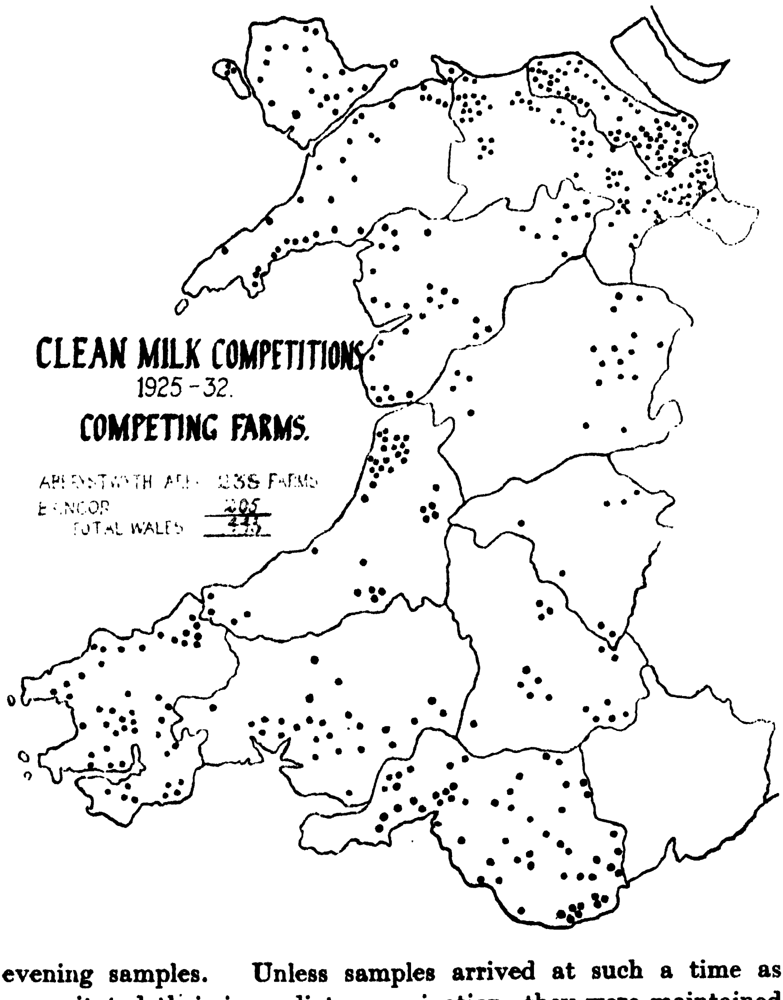
There is no doubt that the organization of clean milk competitions throughout England and Wales has been of considerable assistance in improving the standard of milk production. The object of clean milk competitions is primarily educative and not a purely competitive one. Undoubtedly the competitive side has its advantages, in that it arouses the keenness and enthusiasm of the workers, but the chief value of the competitions lies in the knowledge of clean milk production which the producer is enabled to acquire and put into practice. As a direct result of the knowledge and experience gained through the medium of clean milk competitions many competitors have been enabled to apply for licences for the production of graded milk.

Clean milk competitions were first organized in Wales in 1925, and during the period 1925-32, thirty-six competitions have been held in twelve counties. The distribution of the 443 competing farms is indicated in the accompanying map. These farms are fairly evenly distributed throughout the Principality, though a slightly higher proportion is situated in the milk producing areas of the south and the north-east.

As a general rule the competitions have extended over a period of not less than six months, and have been arranged to include, as far as possible, three months of warm weather conditions. The majority of the competitors are producer-retailers. Up to the last two years "designated" producers have not been discouraged from entering, and it has generally been possible to organize a separate class for such producers. Competitors have also been divided into classes according to the size of their herds, *i.e.*, Class A including herds of less than ten cows, and Class B herds of ten cows or over. All competitions have been carried out on the lines suggested in "The Guide to the Conduct of Clean Milk Competitions" (1).

The number of milk samples taken and examined for each competitor varied from six to twelve according to the organization in the different counties. In each case, however, at least three of the samples were "surprise samples" taken by the

County Agricultural Staff. It was endeavoured, as far as possible, to maintain a standard age at which milk samples were examined, and this was necessarily dependant upon two factors; the time at which milking was carried out, and the time at which samples were delivered at the laboratory. The age of samples at testing generally varied, therefore, from 27-30 hours in the case of morning samples, and from 24-26 hours in the case of



evening samples. Unless samples arrived at such a time as necessitated their immediate examination, they were maintained at an even temperature of 60°F. until examination. The temperature of the samples on arrival naturally varied according to the season of the year, and the atmospheric temperature. The seasonal variation in "arrival temperature" is shown in Diagram I.

Technique of examination.

The bacteriological examination of the milk samples was carried out strictly in accordance with the official routine methods of milk examination outlined in "The Guide to the Conduct of Clean Milk Competitions" (1).

(*a*) Total bacterial count on standard nutrient agar, incubated at 37°C. for forty-eight hours.

(*b*) Coliform organisms content by means of litmus bile-salt lactose medium, incubated at 37°C. for seventy-two hours.

(*c*) Keeping quality, calculated in hours from time of milking, when kept at a constant temperature of 60°F. and tested twice daily.

Samples were tested for butter fat content by the Gerber method, but no marks were awarded, the test being carried out primarily as a check on the methods of sampling.

General hygienic quality.

A statement is made in the recently-published Report of the Re-organization Commission for Milk (2) "that in some parts of the country at least a great deal of the milk produced is now of the "Grade A" standard, though not sold under that designation, and that the bulk of the supply in these areas could with little difficulty be raised to that standard." In view of this expression of opinion it is interesting to find that of over 55,000 milk samples examined from 6,681 competitors who have entered the various County Clean Milk Competitions organized in England and Wales during the past seven years, 66 per cent. have attained the "Grade A" bacteriological standards. Furthermore, it is encouraging to notice that the results in Table I[1] show that even though the competitions have been confined during recent years to producers who have never taken part in a competition before, or who, having competed previously had failed to secure a certificate of merit, there has been a gradual improvement in the hygienic quality of the milk examined.

[1] Reproduced mainly from articles on "Instruction in Clean Milk Production." *Journ. Min. of Agr.*, Vols. 38-39, and *Miscellaneous Publications*, No. 56.

TABLE I.

Clean Milk Competitions, 1925-32.

Area.	*Year.*	*No. of competitors.*	*No. of milk samples examined.*	*No. of samples which reached "designated standards."*	*Per cent. samples which reached "designated standards."*
England ...	1925-6	750	6,206	3,785	61
	1926-7	991	9,797	6,346	65
	1927-8	997	7,592	5,229	69
	1928-9	849	6,424	4,404	69
	1929-30	874	7,359	4,667	65
	1930-1	1,058	9,273	6,340	68
	1931-2	590	4,573	3,419	75
Total: England ...		6,109	51,224	34,190	67
Wales ...	1925-32	572	4,575	2,865	62
Total: England and Wales ...		6,681	55,799	37,055	66

That the standard of hygienic quality attained during the course of competitions in Wales was high, is demonstrated in Table II. Of 4,575 samples examined, 43 per cent. attained the bacteriological standards required for " Certified " milk, and 62 per cent. " Grade A" standards. In the case of seven counties, over two thirds of the samples were within " designated " standards.

Seasonal variation in hygienic quality.

A study of the relative proportion of samples which attain the bacteriological standards of the two designated grades of milk during different months of the year, shows very distinctly the importance of temperature in lowering the standard of quality during the summer months.

From the monthly averages of the " arrival temperature " of over 8,000 samples taken at the two laboratories it will be seen that seasonal variation from 51°F. in January to 63° F. in August is recorded.

The percentage of samples within " Grade A " standards has fallen from 81 per cent. in January to 10 per cent. in August. Over 75 per cent. of the samples taken during the first four months of the year reached " Grade A " standards, but during July, August and September less than 25 per cent. attained this standard. This seems to indicate that eventually, different bacteriological standards may have to be set up in this country

for the winter and summer periods. Some Canadian cities have already adopted this system. For instance, the requirements in Montreal for Certified milk are 10,000 per c.c. for the winter months and 15,000 for the summer months. Toronto, on the

TABLE II.

Welsh County Clean Milk Competitions, 1925-1932.

County.	*No. of competitions.*	*No. of competitors.*	*No. of farms.*	*No. of milk samples.*	*Samples within Certified Bacteriological Standards.*		*Samples within Grade A Bacteriological Standards.*	
					No.	*Per cent.*	*No.*	*Per cent.*
Anglesey ...	4	37	22	305	155	50	207	67
Brecon and Radnor	3	29	23	209	159	76	191	93
Caernarvon ...	2	44	33	307	123	40	188	61
Cardigan ...	2	52	34	354	172	49	251	71
Carmarthen ...	3	33	24	262	143	55	186	71
Denbigh ...	2	86	84	885	295	38	456	51
Flint ...	7	96	66	636	275	43	391	61
Glamorgan ...	2	69	56	549	150	27	261	48
Merioneth ...	3	40	35	263	119	45	176	67
Montgomery ...	2	22	19	175	86	49	126	72
Pembroke ...	6	74	47	630	310	49	429	68
Totals ...	36	572	443	4,575	1,987	43	2,865	62

TABLE III.

Seasonal variation in hygienic quality.

	Jan.	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Totals.*
Total number of milk samples ...	250	336	797	557	554	635	311	132	168	148	165	140	4,393
Number within "Certified" standard	149	320	437	317	285	221	39	7	14	29	49	52	1,918
Percentage within "Certified" standard	59	59	54	56	51	34	12	5	8	19	29	37	48
Number within "Grade A" standard	201	430	608	424	393	334	72	14	41	55	86	84	2,745
Percentage within "Grade A" standard	81	80	76	76	70	52	23	10	24	37	52	60	62

other hand, requires a standard of 10,000 in the summer months and 5,000 in the winter for a similar grade of milk. The

"winter" and "summer" periods could be conveniently arranged as follows :—

"Winter" low count period :—

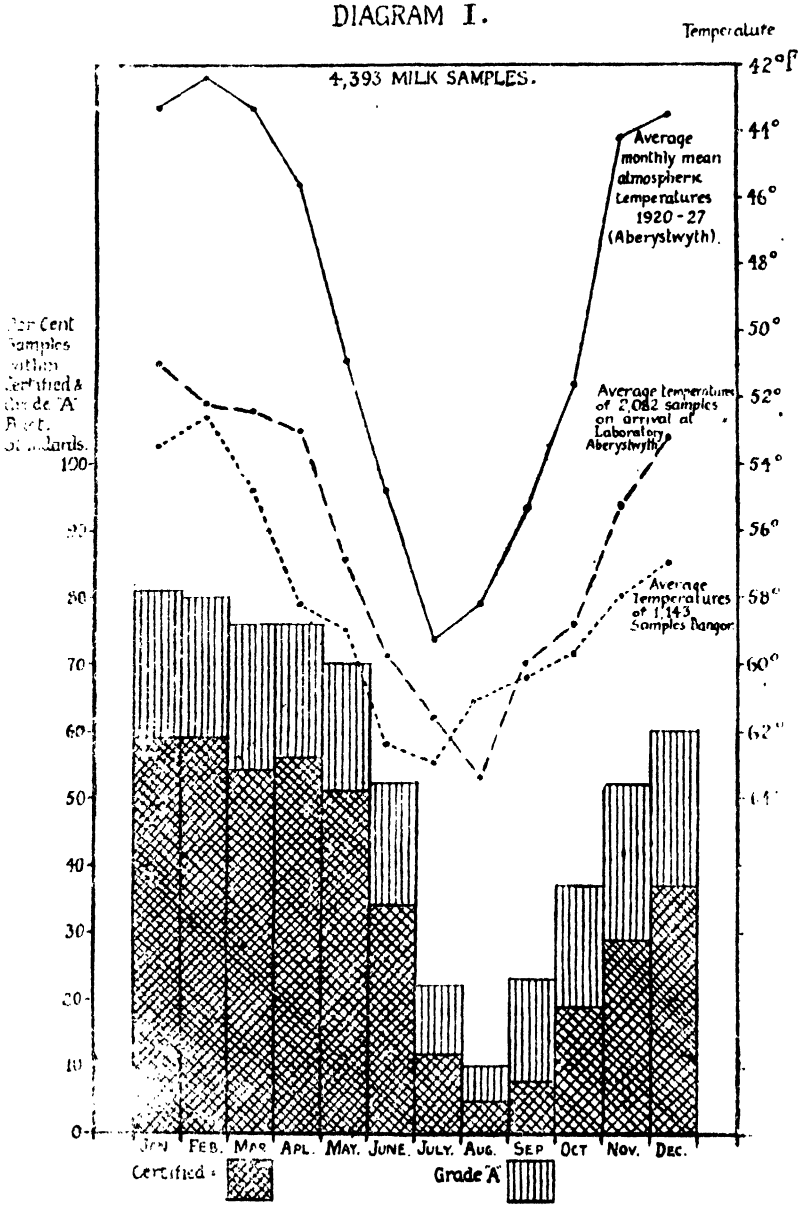
January to May.

November and December.

"Summer" higher count period :—

June to October.

DIAGRAM I.



Seasonal variation in coliform organisms content.

The seasonal variation in coliform organisms content is very marked. Over 50 per cent. of the samples examined during

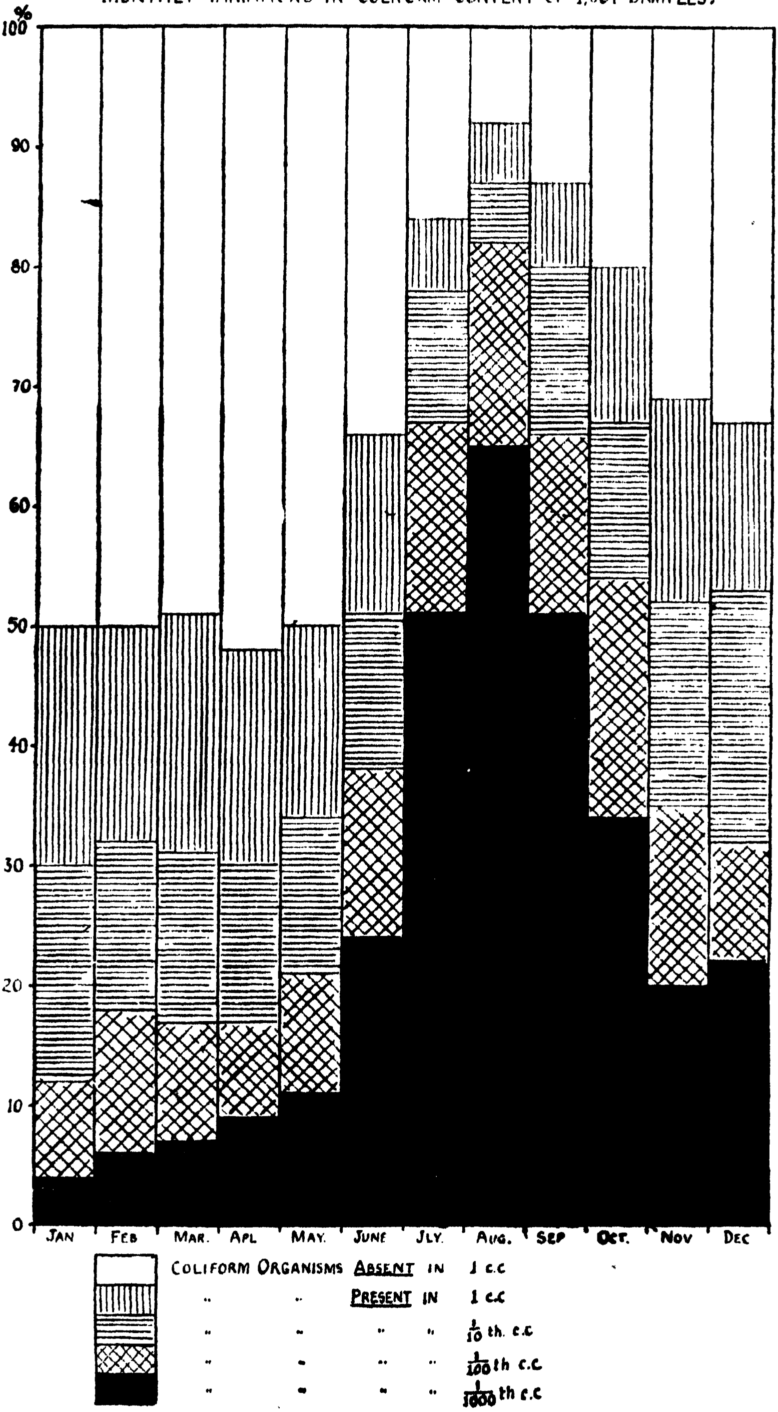
TABLE IV.

Coliform organisms.	*January*		*February*		*March*		*April*		*May*		*June*		*July*	
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
Absent in 1 cc. ...	123	50	287	50	378	49	294	52	281	50	209	34	53	16
Present in 1 cc. ...	49	20	102	18	152	20	100	18	91	16	92	15	20	6
Present in 1/10 cc. ...	44	18	79	14	107	14	71	13	69	13	76	13	35	11
Present in 1/100 cc. ...	19	8	69	12	78	10	43	8	58	10	86	14	52	16
Present in 1/1000 cc. ...	11	4	37	6	53	7	48	9	62	11	144	24	165	51
Totals ...	246		574		768		556		561		607		325	

Coliform organisms.	*August*		*September*		*October*		*November*		*December*		*Totals.*	
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
Absent in 1 cc. ...	10	8	20	13	33	20	56	31	42	33	1,786	41
Present in 1 cc. ...	6	5	11	7	21	13	30	17	18	14	692	16
Present in 1/10 cc. ...	6	5	22	14	21	13	31	17	27	21	588	13
Present in 1/100 cc. ...	21	17	24	15	32	20	28	15	12	10	522	12
Present in 1/1000 cc. ...	81	65	81	51	54	34	36	20	27	22	799	18
Totals ...	124		158		161		181		126		4,387	

DIAGRAM II.

MONTHLY VARIATIONS IN COLIFORM CONTENT OF 4,387 SAMPLES.



July, August and September show the presence of this group in one thousanth of a cubic centimetre. The results for the period

TABLE V.

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Totals*
No. of samples	248	565	770	558	564	607	326	126	157	159	181	126	4,387
Total hours sweet	18,130	45,785	64,962	45,975	43,476	10,879	17,364	6,566	10,007	10,020	13,461	8,882	—
Average hours sweet	73	81	84	82	77	57	53	52	64	63	74	70	—

January to May, on the other hand, are exceptionally good, since no coliform organisms were detected in one cubic centimetre of milk for practically half the number of samples examined.

The temperature of the samples on arrival at both laboratories generally exceeded 60°F. during July to September. Coliform organisms multiply very rapidly when held at temperatures between 60°F. and 70°F. The high coliform content recorded during the summer was, therefore, to be expected, as a certain proportion of the milk samples were not cooled immediately after milking. The results summarised below show that the effect of adverse temperature conditions are more pronounced in their influence on the development of coliform organisms than on the increase of the total bacterial content.

Seasonal variation in keeping quality.

The influence of seasonal variations in bacterial content on the resulting keeping quality is shown in Table V.

A study of these results reveals a definite correlation between the bacterial content and the keeping quality; the July and August samples, on the average, only " keeping sweet " for two and a quarter days, whereas the February, March and April samples exceeded an average of three and a quarter days. Such seasonal variations as are shown in these results point very clearly to the necessity for adequate cooling of milk during the warm weather period. Next to hygienic methods of production and sterilisation of utensils, efficient and immediate cooling is one of the most important factors in prolonging the keeping quality.

Relationship between bacterial content and the keeping quality.

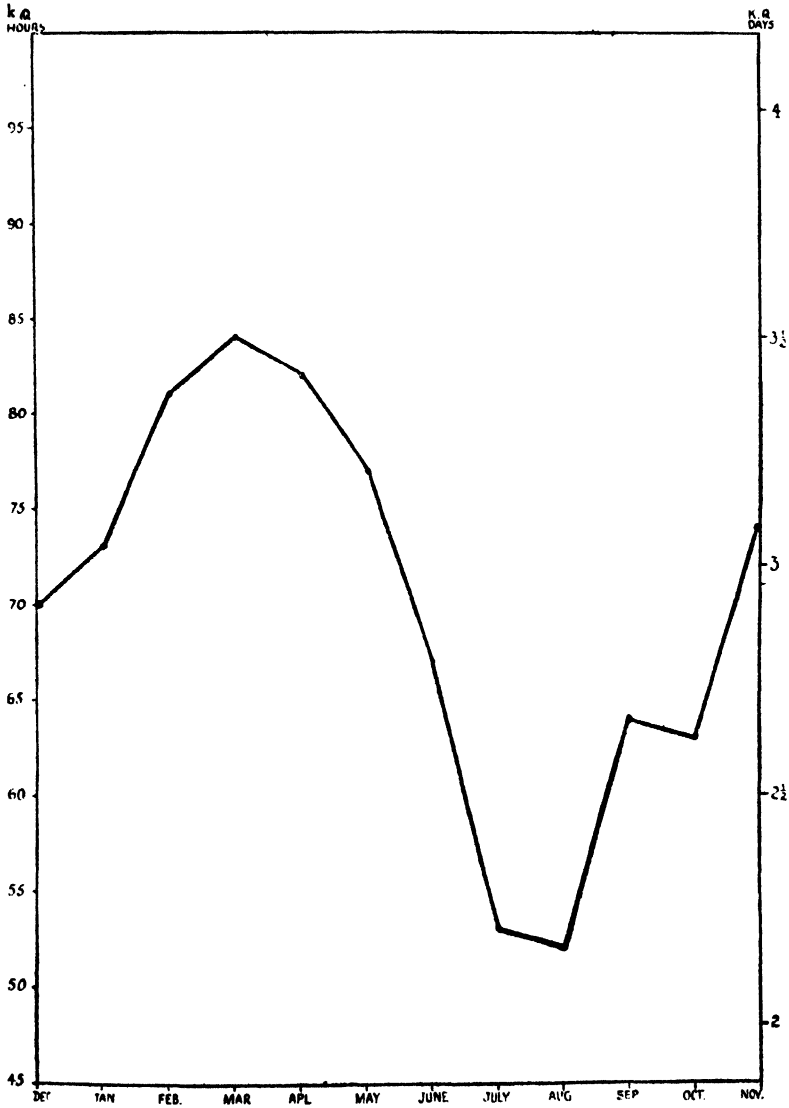
The following data confirm the results obtained by Barkworth, Meanwell, and Taylor in 1929 (3). They demonstrated from the summarised results obtained from eighteen competitions that there is a steady fall in the period of sweetness of the milk as the bacterial count increases, and that the presence of coliform organisms has a markedly deleterious effect on the keeping properties of the milk.

The general trend of the average keeping qualities for the ten bacterial count groups under both sub-sections agrees very closely with the results obtained by those investigators, but a comparison of the actual keeping qualities for each bacterial group shows a considerable difference in the two papers, the results obtained by the present writers indicating longer periods of sweetness. The separate results obtained at the Aberystwyth and

Bangor laboratories also show a similar difference, although the general trend agrees very closely indeed. This is to be expected in a comparative test of this nature, where the personal factor has such an influence on the results obtained.

DIAGRAM III.

AVERAGE MONTHLY KEEPING QUALITY AT 60°F OF 4,387 SAMPLES



A further study of Diagram IV and Table VI shows :—

(1) That the group of 805 samples with the lowest bacterial content (under 1,001 bacteria per cubic centimetre, with coliform

organism absent in 1 c.c.) attains an average keeping quality of four days.

(2) That the group of 487 samples with the highest bacterial content (over 750,000 bacteria per c.c. with coliform organisms present in any dilution up to 1/1000th c.c.) has an average keeping quality of under two days.

TABLE VI.

Bacterial count.	*Coliform organisms not found in 1 cc.*			*Coliform organisms present in any dilution up to 1/1000 cc.*		
	Samples.	*Total hours sweet.*	*Average hours sweet.*	*Samples.*	*Total hours sweet.*	*Average hours sweet.*
1—1,000	305	28,977	95	36	3,178	88
1,001—5,000	651	58,605	90	267	21,815	82
5,001—10,000	241	19,940	83	185	14,801	80
10,001—30,000	288	23,821	83	421	30,185	72
30,001—50,000	77	6,192	80	179	13,266	74
50,001—100,000	79	6,100	77	266	18,314	69
100,001—200,000	46	3,524	77	260	17,311	67
200,001—500,000	51	3,943	77	362	28,153	64
500,001—750,000	19	1,434	75	188	8,777	63
Over 750,000	29	1,764	61	487	21,922	45
Totals ...	1,786	—	—	2,601	—	—

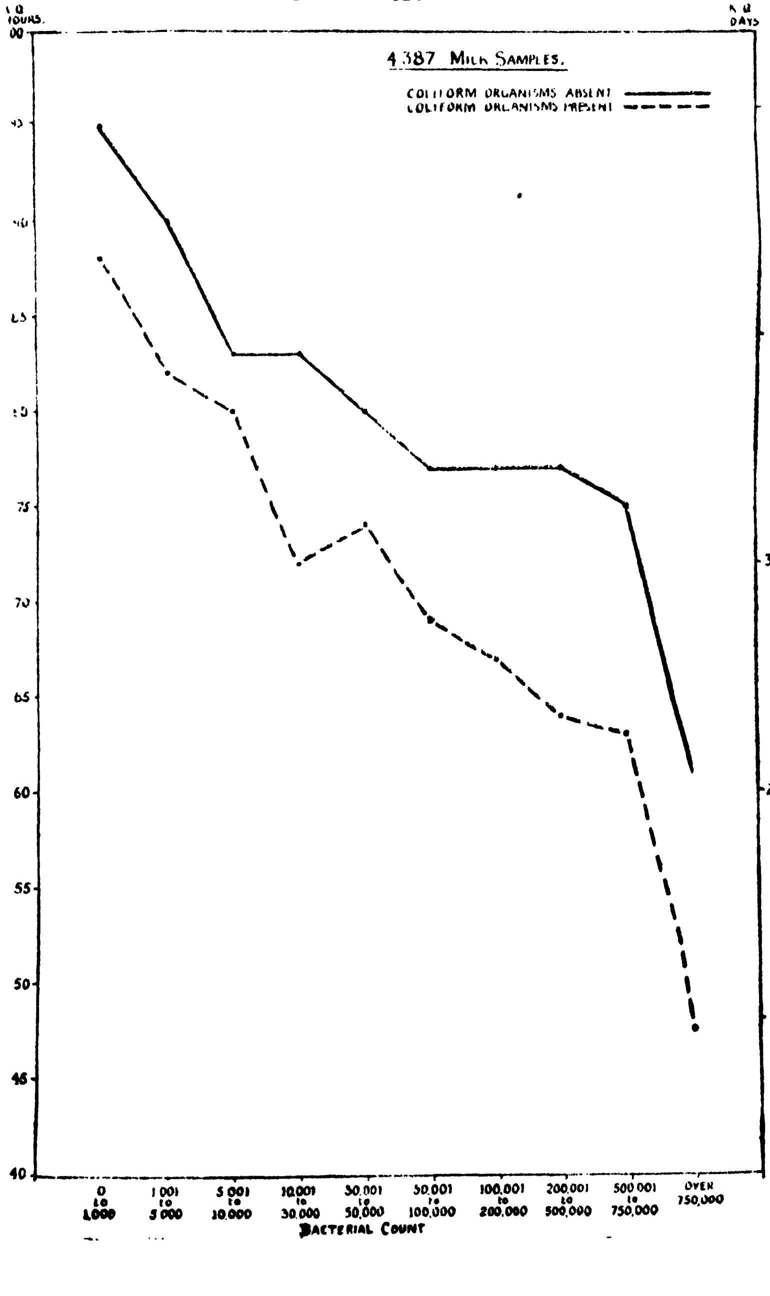
(3) That as the bacterial count increases there is a gradual widening distance between the two curves; thus, the combination of a high bacterial count and the presence of coliform organisms has a progressive deleterious effect on the keeping properties of milk.

(4) That of the 4,887 samples examined only 12 per cent. show bacterial counts above 750,000.

(5) That 76 per cent. of the samples do not exceed a bacterial count of 200,000.

(6) That coliform organisms are not present in 1 c.c. in 40 per cent. of the samples.

DIAGRAM IV.



These results demonstrate very clearly how a particular group of organisms, in this case the coliform organisms, may shorten the keeping quality of any particular series of milk samples, though they have identical total bacterial counts. In comparing the bacterial content and keeping quality of any small series of samples, due consideration should always be given to the qualitative nature of the bacterial flora. It is quite conceivable that a sample with a total count of 20,000 may have a bacterial flora composed mainly of rather inert micrococci, whereas another particular sample with a similar total count may have a flora dominated by rapid souring coliform organisms. In this case a difference of over twenty-four hours in keeping quality may occur.

The importance of efficient sterilisation of dairy utensils.

A comparatively small number of competitors were equipped with efficient steaming plants, but in many cases the maximum use was made of the existing facilities, such as the ordinary farm copper adapted for the purpose. Most competitors who had no means of sterilising by steam were usually careful to scald their utensils with boiling water. Under no circumstances, however, can scalding be favourably compared with steam sterilisation, even when carried out under ideal conditions, as is clearly shown by Proctor and Hoy (4) in their experiments on the relative efficiency of washing, scalding and steaming ten and seventeen gallon milk churns. While good results may be obtained by the scalding method it is infinitely more difficult to maintain them consistently than with efficient steam sterilisation.

The data given below for eighty-seven competition farms show the differences in bacterial count, coliform content, and keeping quality which were obtained with the various methods employed.

The majority of samples from twenty-two farms using steam sterilisation were within " Certified " bacteriological standards, whilst the keeping quality, despite the influence of seasonal factors, attained the exceptionally good average of three and three quarter days. The samples from the forty-four farms using boiling water for sterilisation generally attained " Grade A " standards, but the coliform organism content was much higher, and the keeping quality averaged three and a half days. A large proportion of the samples from the twenty-one farms not using steam or boiling water exceeded a bacterial count of half a million bacteria per cubic centimetre, coliform organisms were present

in most of the samples, whilst the consequent effect upon the keeping quality was most striking.

TABLE VII.

Sterilisation of utensils.	*No. of farms.*	*No. of milk samples.*	*Average number of bacteria per cc.*	*Per cent. samples in which coliform organisms were detected.*	*Average keeping quality (days).*
Efficient steam sterilisation ...	22	157	20,340	29	3.75
Efficient use of boiling water for sterilisation	44	308	61,000	48	3.48
Utensils washed, but not sterilised ...	21	158	467,000	94	1.90
Total ...	87	623	—	—	—

Summary.

The chief facts to be observed from the results of thirty-six Clean Milk Competitions in Wales are :—

(1) That a large number of dairy farms in the Principality in addition to producers of " Graded Milk " are at present producing milk within " designated " standards, at least during the winter, spring and autumn months.

(2) That with the utilisation of efficient sterilisation of utensils and cooling of the milk this standard can be attained by all producers throughout the year.

(3) That there is a very marked seasonal variation in bacterial content and consequently in keeping quality of milk

which is transported for any distance, or kept within the influence of atmospheric temperatures. The adverse effect of such temperature influence is most evident during July, August and September.

(4) That milk produced under hygienic conditions should keep sweet for at least two days in summer and two and a half days in winter, provided it is kept in a reasonably cool place by the consumer during warm weather.

(5) That there is a steady fall in the keeping quality of milk samples as the bacterial count increases, and that the presence of coliform organisms has a deleterious effect on the keeping quality.

(6) That the present methods of routine bacteriological examination give a reasonably accurate indication of the hygienic quality of the milk, and that different laboratories can produce comparative results provided the tests are carried out strictly in accordance with standardised technique.

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MONTHLY VARIATION IN THE FAT CONTENT OF MILK FROM WELSH FARMS.

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AND

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During recent years over 7,000 samples of market milk have been tested for fat content at the Advisory Laboratories at Aberystwyth and Bangor. In all cases the samples were taken in six ounce bottles and tested by the Gerber method within 30 hours of milking. The samples were obtained during the course

of two types of advisory work, namely, Clean Milk Competitions (over 4,500 samples from 443 farms, the distribution of which is shown in the map in the preceeding article), and Local Authority

TABLE I. Afternoon Milk Samples.

Fat Content.	*January.*		*February.*		*March.*		*April.*		*May.*		*June.*		*July.*	
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
Below 3.00 % ...	9	4	6	2	17	4	21	7	26	7	26	7	11	6
3.00—3.49 % ...	42	19	63	15	73	15	41	13	77	20	69	19	22	13
3.50—4.00 % ...	60	27	142	33	168	36	121	39	131	35	137	37	62	37
Over 4.00 % ...	113	50	214	50	213	45	125	41	145	38	135	37	73	44
Total	224		425		471		308		379		367		168	

Fat Content.	*August.*		*September.*		*October.*		*November.*		*December.*		*Total.*	
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
Below 3.00 % ...	5	6	9	6	6	4	1	1	5	4	142	5
3.00—3.49 % ...	6	7	17	12	17	10	11	9	9	8	447	15
3.50—4.00 % ...	25	28	37	26	50	30	34	28	41	35	1008	34
Over 4.00 % ...	52	59	82	56	92	56	75	62	62	53	1381	46
Total	88		145		165		121		117		2,978	

Milk Surveys (the remainder of the samples from approximately 800 farms). The first group was taken at the farm either by the farmer himself or by the County Dairy Instructor from the bulk

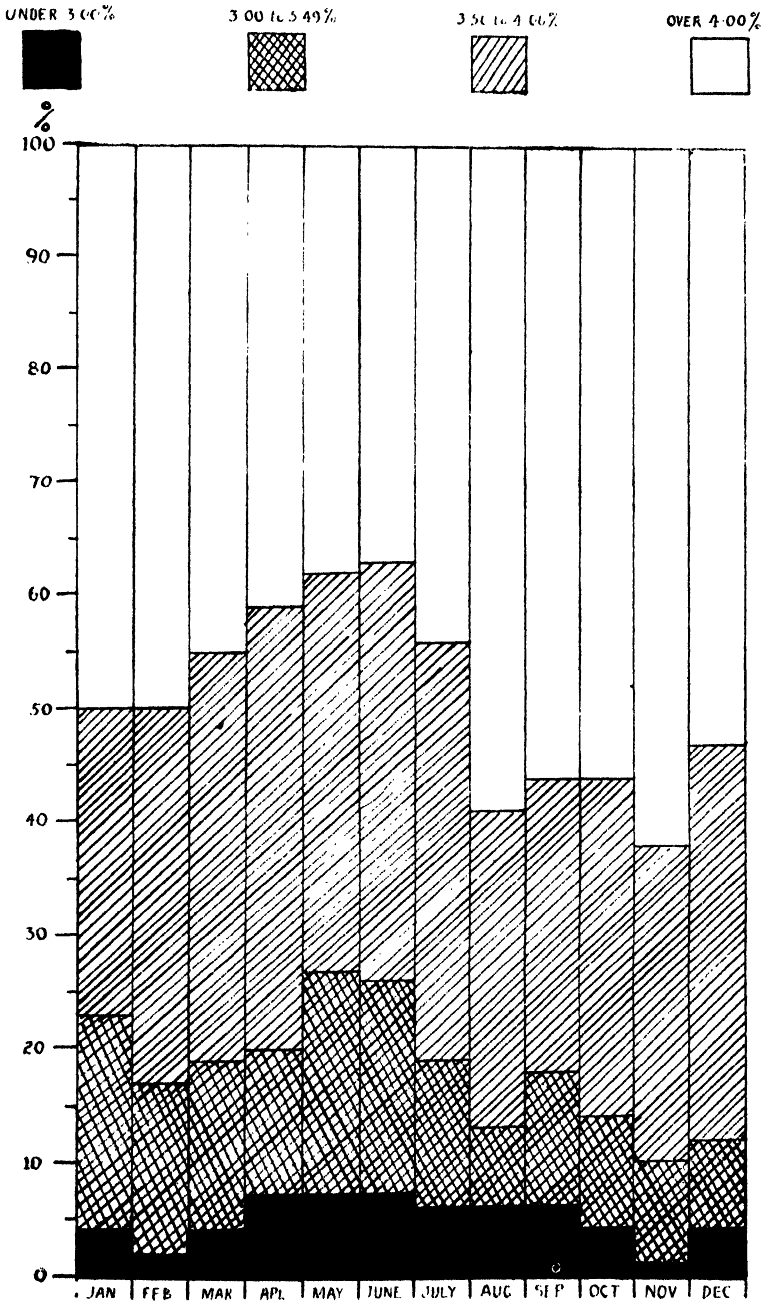
TABLE II. Morning Milk Samples.

Fat Content.	January.		February.		March.		April.		May.		June.		July.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Below 3.00 % ...	30	11	36	11	77	16	99	20	160	27	134	25	98	23
3.00—3.49 % ...	84	31	129	37	204	44	205	42	249	42	213	44	193	46
3.50—4.00 % ...	106	40	120	35	121	26	124	25	134	22	108	20	87	21
Over 4.00 % ...	49	18	59	17	65	14	61	13	54	9	60	11	42	10
Total	269		344		467		489		597		545		420	

Fat Content.	August.		September.		October.		November.		December.		Total.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Below 3.00 % ...	48	25	16	7	20	7	17	5	9	5	714	17
3.00—3.49 % ...	90	47	108	50	84	28	59	19	51	26	1699	39
3.50—4.00 % ...	37	20	53	24	115	39	151	47	81	44	1240	29
Over 4.00 % ...	15	8	42	19	79	26	91	29	19	25	666	15
Total	190		219		298		318		193		4,319	

CHART 1

Afternoon Milk 2978 Samples



afternoon or morning's milk of the herd. The second group was taken by Sanitary Inspectors from the delivery churns on the round, care being taken to differentiate between afternoon and morning milk. Even under such conditions the methods of sampling were often far from satisfactory, since in many cases there was no means of controlling the manner in which the samples were taken.

Requests for information regarding the average fat content of milk from Welsh farms during certain seasons have been frequently received, and a note on the results available might prove of interest.

The actual results of the examination of 7,872 samples are shown in the following tables and charts. It will be seen that the monthly results have been divided into four groups according to fat content :—

(a) Poor milk	under 3.00 % fat.
(b) Milk below the average fat content ...	3.00—3.49 % fat.
(c) Good quality milk	3.50—4.00 % fat.
(d) Rich quality milk	over 4.00 % fat.

The majority of the samples were taken from producer-retailers so that the results at least give an indication of the fat content of the milk as received by the consumer in such cases.

Afternoon.

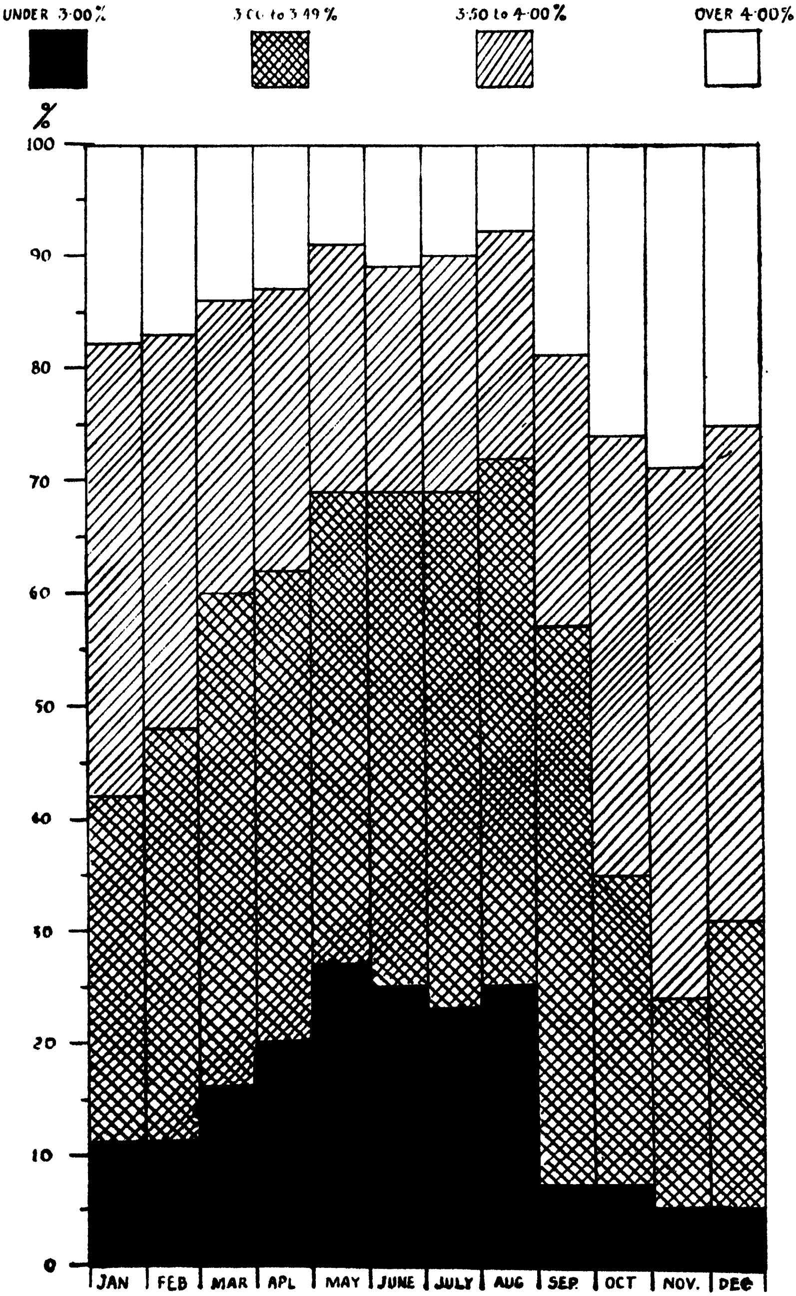
It is interesting to find that with the exception of milk taken during March to July, 50-60 per cent. of the samples contained over four per cent. fat. Even during the five spring and summer months practically 40 per cent. of the milk contained over four per cent. fat. There is no very marked seasonal fluctuation in the fat content of afternoon milk samples, although a slightly richer milk is retailed during the winter and autumn. Of practically 8,000 samples, only 5 per cent. contained less than three per cent. butter fat.

Morning milk.

The fat content of the morning milk was not only much poorer, but also showed great seasonal variations. The average results for over 4,000 samples show that only 15 per cent. contained over four per cent. fat. The samples taken during May, June, July and August were particularly poor in fat content, practically 25 per cent. containing less than 3 per cent., and 70 per cent. less than three and a half per cent. The autumn and winter samples were again much richer in butter fat, but contained considerably less in comparison with the afternoon samples for these periods.

CHART 2

Morning Milk 4.349 Samples.



Circumstances affecting the butter fat content.

The Sale of Milk Regulations, 1901, provide that a sample of milk which contains less than three per cent. of butter fat is to be presumed, for the purposes of the Food and Drugs (Adulteration) Act, 1928, not to be genuine unless the contrary is proved. It is well known, however, that the introduction of certain factors will tend to lower the fat percentage of milk without adulteration having taken place.

(*a*) *Small herds.*

Fairly accurate information has been obtained as to the size of the herds on farms entered in the Clean Milk Competitions. From 40 to 50 per cent. of the farms keep a herd of 10—20 cows, only 10 to 20 per cent. have a herd of over 20 cows, whilst over 30 per cent. have less than 10 cows in milk.

Although the limit of three per cent. fat is lower than the average percentage of mixed milk from a fair-sized herd, it is often found that the milk of an individual cow may fall below this standard at certain seasons or under different conditions of management and milking. In the case of small herds of 6—10 cows the presence of two or three such cows may bring the fat content of the bulk milk below the presumptive limit. That the effect of the individuality of cows is more marked in small herds is well known. A study of Table III reveals the fact that out of 436 samples from small herds, 17 per cent. contained less than 3 per cent. butter fat as compared with 11 per cent. of the same number of samples taken from larger herds. On the other hand it is strange that the proportion of " medium " samples, *i.e.*, 3.00 per cent. to 4.00 per cent., is about the same in the small herds as in the case of the larger herds, while the proportion of samples containing over 4 per cent. of fat is distinctly lower. It is possible that the number of results obtained is too few to enable a general conclusion to be drawn therefrom, but it would appear that there is probably some factor involved which influences the low fat content other than that of the individuality of the cow.

(*b*) *The milk bottling problem.*

In cases where milk is bottled on the farm, a large proportion of the producer-retailers bottle direct from the cooler, and in many cases the container above the cooler is only capable of holding the milk of two to three cows, which may be milk of a low fat percentage. Thus the bottled milk is often not well mixed and the individuality factor again plays an important part. Quite a large number of the samples taken by the farmers

during Clean Milk Competitions were taken under such conditions.

TABLE III.

Milk samples from eighty-five farms arranged according to size of herd.

	Morning Milk Samples from small herds (eight cows and under).		*Morning Milk Samples from larger herds (over eight cows in herd).*	
	Number of samples.	*Per cent.*	*Number of samples.*	*Per cent.*
Under 3.00 per cent. fat ...	73	17	48	11
3.00–3.49 per cent.	136	31	138	32
3.50–4.00 per cent.	129	30	117	27
Over 4.00 per cent.	98	22	133	30
Total ...	436	100	436	100

The following table gives the fat content of 127 pint bottles of morning milk taken at random during the course of twelve months from ten farms where the milk was bottled direct from the cooler :—

TABLE IV.

Fat content.	*Number.*	*Per cent.*
Under 2.00 per cent.	7	6
2.00–2.90 per cent.	26	20
3.00–4.00 per cent.	57	45
4.10–5.00 per cent.	22	17
5.10–6.00 per cent.	9	7
Over 6.00 per cent.	6	5
Total ...	127	100

The results show extreme variation, a large number of samples containing less than 2 per cent. fat, a similar proportion, on the other hand, containing over 6 per cent.

(*c*) *Intervals between successive milking.*

A large proportion of the producer-retailers deliver their milk twice daily, particularly during the summer months May to August, the afternoon delivery generally taking place from 4.30 p.m. to 5.0 p.m. Under these conditions the intervals between successive milkings are often fifteen and nine hours (milking 6 a.m. and 3 p.m.), and the fat percentage is generally very low in the morning's milk.

Summary.

The results of the analyses for fat content of 7,372 random samples from the bulk milk of over one thousand herds show :—

(1) That the afternoon milk generally contains a high fat content, a large proportion of the samples examined containing over 4 per cent. Only 5 per cent. of the samples failed to reach the 3 per cent. presumptive standard.

(2) That there is very little seasonal fluctuation in the fat content of afternoon milk.

(3) That not only is the fat content of morning milk much lower, but very marked seasonal fluctuations occur. Practically 25 per cent. of the samples tested during May to August contained less than 3 per cent. fat.

(4) That the large number of morning samples which fall below the presumptive standard during the period May to August may be attributed to a certain extent to the following local circumstances :—

(*a*) A large proportion of the dairy farms have less than ten cows in milk.

(*b*) Producer-retailers often bottle their milk directly from the cooler, the container of which may be only large enough to hold the milk of two to three cows, and a random bottle may therefore contain milk from cows which yield a low fat percentage.

(*c*) Producer-retailers who deliver their milk twice daily during this period, milk at very irregular successive intervals.

SEASONAL VARIATIONS IN THE KEEPING QUALITY OF BUTTER FROM FIVE FARMS.

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An examination of the results of county butter competitions conducted in the Aberystwyth Advisory Area showed wide variations in the keeping properties of farm-produced butter, and it was evident that these fluctuations were in some measure due to seasonal factors. As the majority of butter competitions were only conducted over a period of six months it was decided to study the quality of butter from a number of individual producers over a complete period of twelve months.

Five producers who were known to be producing good quality butter kindly undertook to forward samples of unsalted butter to Aberystwyth each week on the day of churning. The first samples were received during the first week of May, 1931.

All samples were examined at approximately twenty-four hours old and were scored in accordance with the following score card :—

	Max. points.
Flavour and aroma ...	50
Body and texture ...	25
Incorporation of moisture ...	15
Colour ...	10
	100

The samples were then placed in a low temperature incubator at 60°F. and were tested for keeping quality on alternate days. The life of a sample ended when it developed a pronounced " off " flavour or taint.

The method of grading adopted for the use of butter competitions (1) (2) was followed during this investigation.

Table I shows the distribution of the samples in the various grades.

TABLE I.

	No. of samples.	*Per cent.*	*Average keeping quality.*
Grade I. Minimum score 85 ...	123	68.6	19 days.
Grade II. Minimum score 80 ...	47	26.3	16 days.
Grade III. Minimum score 75 ...	18	4.5	14 days.
Below Grade III. ...	1	.6	11 days.

Number of samples examined, 189.

From the above table it will be seen that the majority of butters examined were placed in Grade I, and that the highest grades attained the best keeping qualities. These results emphasize the fact that the butters examined were of good quality, and superior to those examined during the course of the butter competitions.

The distribution of 410 competition samples in the various grades is shown in Table II.

TABLE II.

Grade I	24.1 %
Grade II	39.7 %
Grade III	26.9 %
Below Grade III	9.3 %

The producers who forwarded butter samples for this investigation were from the counties of Cardigan, Merioneth and Pembroke.

Farm A.

At this centre churning was carried out once weekly throughout the year, there was always a demand for fresh cream from this farm and consequently the churnings were small. The herd consisted of seven cows and was made up of Welsh Blacks and Shorthorns.

Farm B.

The herd consisted of 14 Shorthorn cattle and churning was carried out once weekly.

Farm C.

Churnings were carried out once weekly from a herd of 20 Shorthorns and two Guernseys.

Farm D.

At this centre butter was made from whole milk. For the period May to the end of December churnings were made twice weekly, from the end of December to mid-February once weekly and then once fortnightly until the end of April. The herd was made up of Welsh Black Cattle.

Farm E.

Churnings were carried out twice weekly during the period May to the end of September and then once weekly during the remaining period. The herd consisted of 23 Shorthorn cattle.

With the exception of Farm D, cream separators were used in each case.

The average monthly keeping qualities of the butter received from each farm is shown in Table III.

The poorest flavoured butter was produced during the months December to April inclusive, whilst the four worst months from the point of view of keeping quality were December, January, February and March.

During the latter period the herd is housed entirely indoors, and the quantity of milk which is available for butter-making purposes is relatively small, with the result that churning takes place at less frequent intervals. Cream which has been collected

TABLE III.

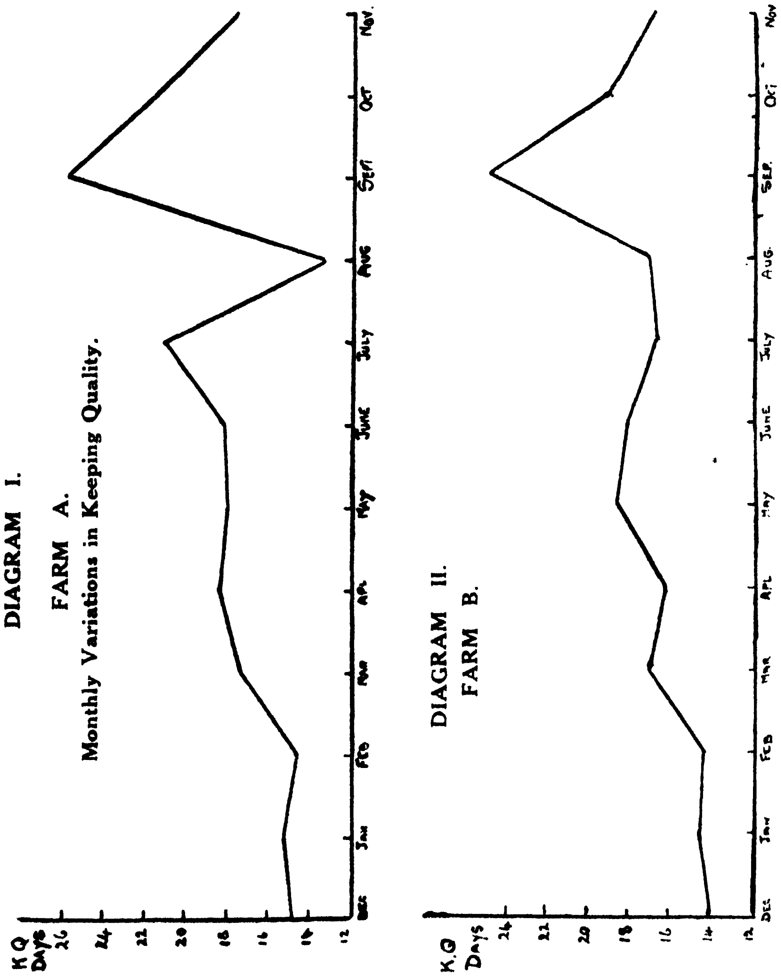
Month.	Average keeping quality in days.					*Average keeping quality of five farms.*
	Farm A.	*Farm B.*	*Farm C.*	*Farm D.*	*Farm E.*	
December	11.80	15.50	11.30	15.50	25.00	16.40 days.
January	15.25	14.50	14.75	12.50	13.00	14.00 days.
February	14.50	14.30	9.75	14.25	13.00	13.20 days.
March	17.40	17.00	15.75	17.00	13.25	16.00 days.
April	18.25	16.30	17.50	—	18.70	17.68 days.
May	18.00	18.50	13.70	19.00	16.00	17.00 days.
June	18.20	18.00	18.00	19.00	23.30	19.30 days.
July	21.25	16.75	20.50	21.00	26.50	21.20 days.
August	13.25	17.00	24.70	21.50	23.75	20.00 days.
September	26.00	24.75	26.25	24.00	—	25.25 days.
October	21.75	19.00	14.00	19.60	23.00	19.35 days.
November	17.50	16.75	16.75	20.00	23.75	19.00 days.
No. of samples	51	46	39	38	31	*Tot. sam.* 205

over too long a period will not yield a good flavoured butter—such butter will possess acid and stale flavours and the keeping quality will be poor.

One of the chief objects of cream ripening is to obtain the desired flavour and aroma which is characteristic of good butter. During the ripening period the cream should be held at a temperature which favours the growth and development of the flavour and aroma producing bacteria. Suitable ripening temperatures will lie between 60°F. and 68°F. Temperatures below 60°F. encourage the development of undesirable types of organisms and these will give rise to bad flavours.

Under farm conditions difficulty is often experienced in maintaining the cream at suitable temperatures during the winter months.

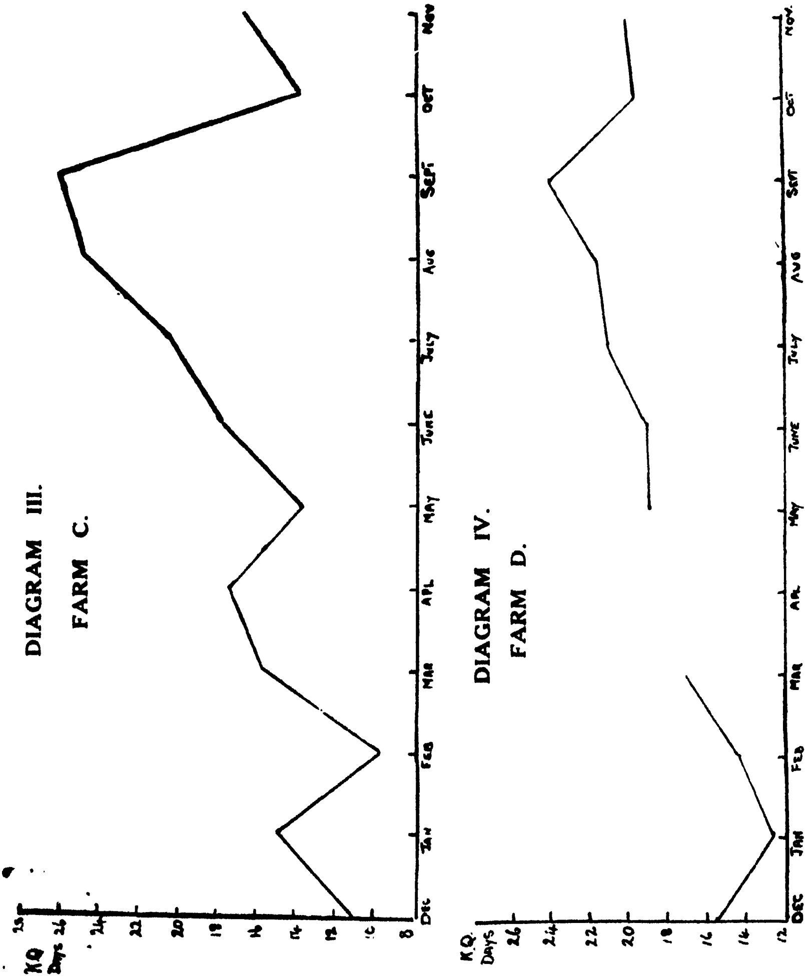
A slight improvement in keeping quality is recorded during April and May while a greater improvement is recorded during



June and July. The butters produced during August show a slight falling off in keeping quality, but those produced during September attained the highest keeping qualities recorded during the twelve months.

In a previous article (2) it was pointed out that "Leaky" butter possessed a poorer keeping quality than butter which had been thoroughly "worked" and where the moisture was incorporated in the form of minute droplets.

Spring and early summer butter is invariably soft and oily in texture, consequently it will not stand much working and this leads to an incomplete incorporation of the moisture. September butter, on the other hand, possesses a much firmer body. Such a butter will stand considerably more working and this will lead to a thorough incorporation of the moisture.



Keeping properties recorded during October and November show a slight downward tendency as compared with those of the previous months.

Diagrams 1—5 show the average monthly keeping quality of butters examined from each of the five farms, whilst the

monthly averages of all samples is shown in diagram 6. Diagram 7 gives the average monthly "score" of all samples as judged on arrival at the laboratory.

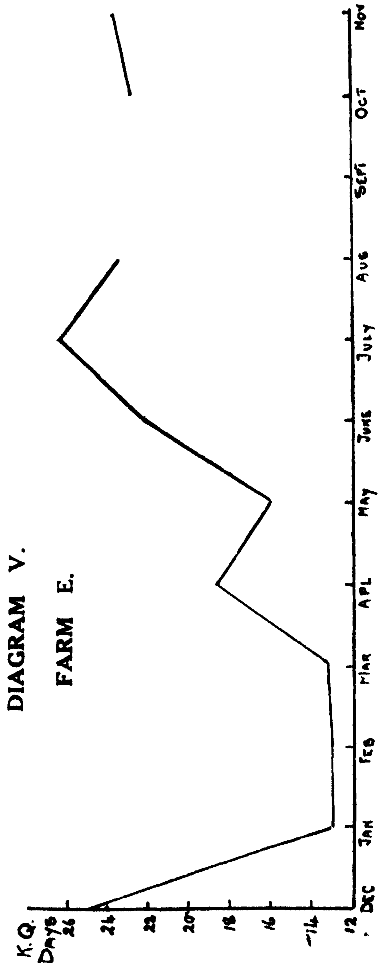


DIAGRAM V.

FARM E.

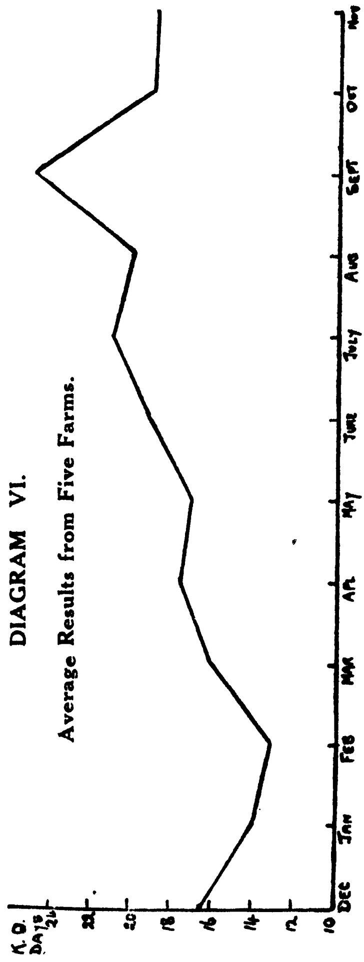


DIAGRAM VI.

Average Results from Five Farms.

Summary.

The examination of 205 weekly butter samples from five butter producing farms over a period of twelve months show :—

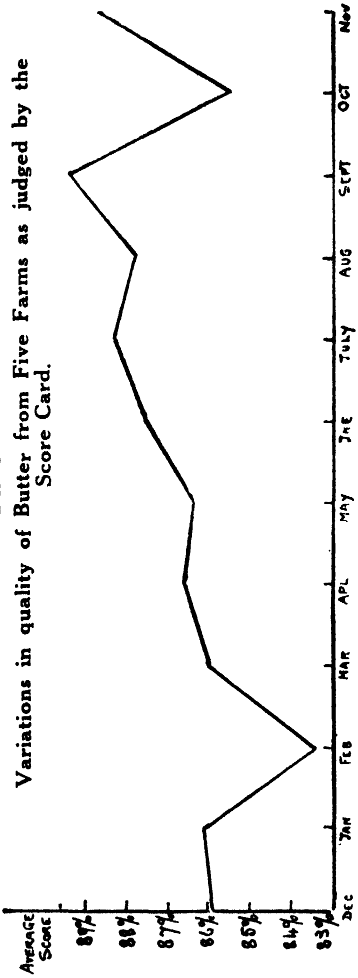
1. That there is a close correlation between the keeping quality and the score awarded on arrival at the laboratory.

2. That the best butter is produced during the period July to September whilst the poorest butter is produced from December to March.

3. That seasonal fluctuations from each of the five farms agree fairly closely.

DIAGRAM VII.

Variations in quality of Butter from Five Farms as judged by the Score Card.



Acknowledgements.

The writer wishes to record his thanks to the following ladies who kindly undertook to supply the butter samples for this investigation :—

Mrs. G. Jones, Cwmconnel, St. Dogmaels.
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Mrs. M. Lloyd, The Lodge Farm, Crosswood.
Mrs. E. Roberts, Ddol Fawr, Llanuwchllyn.
Miss S. M. Roberts, Penisa'rllan, Bala.

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ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

AGRICULTURAL ECONOMICS.

Abstractors :

J. Llefelys Davies, M.Sc., J. Glynne Williams, B.Sc., M.S., W. H. Jones, B.Sc., R. Henderson, B.Sc.

ACCOUNTS AND COSTS.

Agriculture in the Eastern Counties of England—an Economic Survey of.
Report No. 19. Farm Economics Branch, Department of Agriculture, University of Cambridge.

The information contained in this Report is based upon survey data collected in England during 1931. Farmers in the six counties of Norfolk, Suffolk, Essex, Hertfordshire, Cambridge and Huntingdonshire were visited and records from 1,028 farms were obtained. The Report is largely of a descriptive character and is mainly concerned with determining the nature and extent of the agricultural situation at that time. Only holdings of over twenty acres are included, whilst fruit, market garden and hobby farms were omitted.

A somewhat new concept is introduced into the analysis being the "profit surplus"; this is the surplus which remains after subtracting from the farm income an allowance for the occupier's own labour and also 5 per cent. on the farm capital. When this method is applied for testing the profitability of the holdings it was found that in order to provide 5 per cent. on capital and 48s. per week for the farmer's manual and managerial labour, prices would need to be 18 per cent. higher.

Comparisons of profitability are made between groups of farms on which the systems of farming are different and it is shown that better results were obtained on the livestock farms than on the crop farms. Some interesting information is given regarding the factors which have an influence on profits. Heavy output per £100 spent on labour was found to be associated with relatively high profits. Further, incomes were generally higher on holdings which turned over from two-thirds to three-quarters of their capital in a year, than on those which turned over less. The most important factors influencing profits were found to be: efficiency of labour in terms of output, the rate of turnover, the efficiency of livestock production in terms of output per £100 worth of food, the size of the farms measured in terms of output.

W.H.J.

Farm Profits—an Experiment in the interpretation of.
E. Whittaker, East of Scotland College of Agriculture, Edinburgh. Report from *Scottish Journal of Agriculture.*

This paper describes an experiment in methods for the study of farm management. The first part deals with the cross tabulation method as an aid in finding the factors associated with income. In the second part the results of applying the mathematical method of multiple correlation are presented. Comparison is made of actual profits on the holdings investigated with those estimated by calculation.

W.H.J.

Horse Labour—the cost of.

Report No. 15. JAMES WYLLIE, South-Eastern Agricultural College, Wye, Kent.

This investigation attempts to throw some light on two questions that are of general interest (1) what has been the average annual cost of keeping a farm horse during the last two years and (2) what has been the cost per hour of work done. Cost is made up as follows:—

		£ s. d.	£ s. d.
Foods:	Purchased ...	2 6 1	
	Home grown ...	15 1 7	
	Grazing ...	2 9 3	
		19 16 11	
Less manure ...	...	1 18 1	
Net cost of foods	...	...	17 18 10
Depreciation on horses	...	...	4 8 8
Man labour	...	...	1 0 0
Shoeing ...	...	...	2 4 5
Harness repairs	...	...	1 2 1
Equipment	...	...	0 19 7
Vet. and Medicines	...	...	0 7 10
Sundries ...	...	...	1 2 4
Total ...	...	...	£29 3 9

The net cost per horse per week ... ... = 11s. 3d.
Cost per horse hour ... ... = 4.5d.
Average number of hours of work per horse per week = 30

This Report is a continuation of a previous statement and deals with results during the years 1926 to 1931.

During the first three years the average cost of keeping a horse was £36 or 13s. 10d. per week or 5.4d. per hour, but during the last two years the respective figures have been £30, 11s. 6d., 4.4d. The average working week was 31¼ hours. W.H.J.

Milk Production—some aspects of economic.

JAMES WYLLIE, South-Eastern Agricultural College, Wye, Kent.

This paper was read before the Conference of Agricultural Organisers at Cambridge in 1931. The development of milk production as a specialised enterprise is touched in the early part, with some reference to the Harley and Hosier systems. Particular stress is laid upon the duties of those persons who are called upon to advise farmers in the better methods of organising milk production as an industry. Mr. Wyllie suggests that at present too much stress is laid upon making the existing organisation as perfect as possible and too little on general organisation upon different lines. The importance of such matters as cost of production, milk yield per cow and financial return are also briefly dealt with in the paper. W.H.J.

Milk Production over five years, 1926-7 to 1930-1.

JAMES WYLLIE, South Eastern Agricultural College, Wye, Kent. Report No. 14.

During the period of five years over which this investigation extends, the college farms were in the process of building up a Tuberculin Tested

herd; an enquiry was therefore conducted into the financial aspect of the problem. When tuberculin testing commenced nineteen reactors were found amongst a herd of sixty-three cows, which amounts to 30 per cent. of the total. Again during the year when tuberculin testing was begun the loss on the milking herd was £182 and on the other dairy stock £257. In the last two years, however (1930-31) the cows left a profit of £384, but there was still a loss of £215 on the other dairy stock.

Many factors appear to have contributed towards this improvement——by the end of the period cost of labour fell from 5.58d. to 4.09d. per gallon, cost of foodstuffs from 8.3d. to 6.39d., and the cost of depreciation on the cows from 1.43d. to .01d.

This is a very interesting publication; it deals very fully with the cost of improving a herd of cows, but it is not claimed that the results submitted are representative of those on ordinary milk farms.

W.H.J.

MARKETING; CO-OPERATION; PRICES.

Collective Bargaining Organisations; A price plan for selling Milk by.
R. W. BARTLETT. Bulletin 251, Pennsylvania State College, Pennsylvania.

The organisation of producers and distributors in the milk trade of this country has developed so far as to enforce upon both groups the necessity for amicable settlement of prices to be paid. Any publication which details a practical attempt to formulate a basis upon which an adequate price system can be based is therefore of interest. Price plans have been quite common in the United States and have met with varying success.

This publication is the result of a careful study of a number of price plans which have been adopted, and, by analysis and criticism, it attempts to show the strength and weakness of the individual schemes. The analysis of consumption and production of milk plus the review of price plans assists the author in drawing out certain fundamental principles upon which the price-determining process must be based.

The bulletin concludes with a detailed description of the Pittsburg Equalizing Value Price Plan in which an attempt has been made to combine the sound elements of existing price plans with such new elements as seemed necessary in order to adhere to the basic principles outlined.

J.G.W.

Dairy Produce, Report on the marketing of Butter and Cream.
Part 2, Economic Series, No. 30, Ministry of Agriculture, H.M. Stationery Office, London, 1932.

Two previous Reports of this series have dealt with the marketing of milk and cheese respectively. This Report is concerned with butter and cream.

Both these commodities have peculiar characteristics in common. The main one being the relatively low consumption of the home produced commodity per head of the population. The extent to which an increased consumption in either would relieve the liquid milk market is an interesting problem, and only a detailed knowledge of the market for both products will permit of a reasonable answer. These studies are therefore of value not only as they give a basis for the possible improvement in the marketing of the respective commodities but in placing

definite information before persons interested as to the nature of supply, both imported and home produced, and the peculiarities of demand.

The importance of foreign supplies of butter on the market necessitates a detailed statement of the organised methods of sale and the systems of quality control adopted by these countries. The possibility of standardisation of home produced butter is discussed, and an outline is given of a National Mark Scheme for Creamery Butter. There is also the suggestion that the development of creameries in suitable areas may follow from the rationalisation of the milk industry.

The study of the cream market also includes a suggested outline for a National Mark Scheme. This has not been propounded because of foreign competition but to assist purchasers and maintain confidence in the quality of the product. It is made clear that it is most difficult for the consumer to estimate the quality of cream by inspection. The importance of canning cream is fully appreciated, and it is suggested that in spite of the present small scale of cream canning the possibility of marked development in the near future may call for a National Mark Scheme for this commodity independent of any scheme for fresh cream.

J.G.W.

East Bay Milk Market, An analysis of the.

J. M. Tinley and Martin H. Blank. Bulletin 534, Giannini Foundation of Agricultural Economics, University of California, Berkeley, Cal.

After a "Milk war" lasting several months the Giannini Foundation were called upon, as an independent body, to make a detailed study of the economic factors affecting the marketing of whole milk in the area concerned. The bulletin presents in detail the information collected in the course of the study. The investigation covered demand and supply of fluid milk, together with a survey of transportation and distribution methods. In the final recommendations the authors suggest that in order to maintain demand, a scheme of industry advertising should be adopted as this would be far less expensive than competitive advertising by individual distributors. They also maintain that distributors should make a concerted effort to introduce every possible economy in distribution and that one form of economy which could be adopted is for producers and distributors to concentrate the hauling of milk in the hands of one agency. As it does not seem possible to establish the buying and re-sale prices of milk on the basis of any formula, it is suggested that a milk trade board be set up to collect and analyse information relative to the economic factors influencing production, distribution and consumption in the area. It is then suggested that producers and distributors should meet this milk trade board periodically to fix prices.

J.G.W.

Livestock Movements in Cornwall and Devon, A study of.

J. J. MacGregor, M.S., B.Sc., N.D.A.

In these days of Marketing Act and Marketing Schemes a more detailed knowledge of the movements of farm animals between the time and place of their production and the time and place of their consumption would serve a useful purpose. In fact, if ever any rationalised and systematised marketing scheme for live stock is to be carried out, this detailed knowledge will be essential. Organised marketing of any farm product predetermines a survey of existing methods of distribution, and a systematic analysis of all available records of the movements of the

product from its centre of production to the area or locality in which it is consumed. Mr. MacGregor has rendered a signal service by producing the results of his survey at the present time. If what he has done in Cornwall and Devon could be done for every other county in England and Wales, then a wealth of detailed information would be compiled and could at once be placed in the hands of any committee or commission appointed for the purpose of working out a marketing scheme. The information would provide a working basis not only for re-organisation, but for the effectation of major economies related to distribution. Mr. MacGregor has collected details of the distribution of cattle, calves, sheep and pigs, both as exports from and imports into the two counties concerned. As might be expected in counties where live stock production is predominant the export trade assumes by far the greater importance, and it is with these that the work is mainly concerned.

Shipments of the four classes of live stock from the railway stations have been analysed, and the total numbers consigned to numerous counties in England and Wales are indicated, and thus it is possible to appreciate at a glance those which occupy a prominent position in the live-stock trade of the two counties. With regard to imports, the counties from which they are derived are discovered in the same way. In making use of railway station live-stock records, therefore, Mr. MacGregor has been able to indicate the direction of both the outward and inward trade.

Statistics of railway traffic, however, do not cover the whole of livestock movements. Road transport now accounts for some proportion, but for the longer distance as between counties nearby or remotely distant, it may be assumed that practically all the traffic is carried by rail. Figures of road traffic would not, therefore, materially affect any conclusion arrived at as to the general direction of live-stock movements.

The analysis has been carried further within Cornwall and Devon. Here it is seen that certain areas are more definitely engaged in export to counties at a distance than are others.

The work is supported throughout by tables which are at once intelligible and elucidating, and although these give figures for the year 1930, the work is a useful contribution to applied agricultural economics, particularly in view of existing conditions in the agricultural industry and the changes which are likely to be effected in marketing.

R.H.

Marketing Activities of the North Dakota Agricultural College.

A. H. Benton and H. L. Dalster, North Dakota Agricultural College, Fargo, North Dakota.

The North Dakota Agricultural College was one of the first agricultural institutions in the United States to offer a separate course in marketing. Market grades, principles of grading and similar topics are taught by various departments in the College, the Department of Agricultural Economics teaching the Economic Principles of Marketing. This report is published by the latter department and gives details of the courses offered as well as giving a brief report of all the marketing activities and research topics undertaken.

As it shows the wide range of activities which can be profitably undertaken by an agricultural institution offering direct service to the general farmer it is a publication of interest to all agriculturists in these days of marketing reorganisation. **J.G.W.**

Milk Manufacturing.

F. J. Prewett. Agricultural Economics Research Institute, Oxford. (Oxford Clarendon Press).

This survey is one of a series of surveys of milk production and distribution in different areas in this country. It is the first attempt to detail the conditions of use of milk in an area of small farms, where most of the milk is used for manufacturing purposes. The area surveyed is West Cornwall, and the study the records of 27,674 dairy cows owned by 3,607 milk producers. The material is interesting and fresh, because of the vast difference in use of milk shown for this area as compared with other districts in this country. The broad comparison between West Cornwall and Derbyshire is set out as follows, and illustrates this point.

	Percentage of production.	
	Derbyshire.	*West Cornwall.*
Wholesale	74.8	39.1
Producer-retail	14.2	6.3
Domestic manufacture	2.4	45.0
Calves and home consumption ...	8.6	9.6

Of the milk sold liquid by the farmer only about half was used for liquid consumption, equivalent to no more than 12 per cent. of the total milk produced. Details of use of milk for manufacture are interesting, the main products of the creameries being butter and cream for sale. In some cases milk is collected by the manufacturers, while in other cases the milk is separated on the farm and the cream collected. Details of the differential prices paid or values realised per gallon of milk used for different purposes are given, and the contrast between prices realised for milk sold for liquid consumption and that used for butter-making either on farms or in creameries is striking. The main problem of the "liquid" and "manufacturing market" for milk is well illustrated by this survey, and it is to be hoped that more studies of this kind can be undertaken leading to analysis even more comprehensive than in this case.

J.Ll.D.

Pigs and Pig Products, Report of the Reorganisation Commission for.

Economic Series, No. 37. Ministry of Agriculture, H.M. Stationery Office, London.

Under the Agricultural Marketing Act reorganisation commissions could be set up to study the methods of improvement in the marketing of specified products and to outline schemes to be operated within the powers of the Act. This report consists of the findings and the recommendations of the first commission to be set up.

To those interested in the general problem of marketing of farm products it gives an excellent guide to the attitude of the Government to future development, and in fact shows the marked change in policy which has been adopted since the passing of the Agricultural Marketing Act. It gives an excellent review of the difficulties, and also offers suggestions as to the best methods in the opinion of the Commission, to overcome these and place the business of pig production on a satisfactory and expansionist basis.

Whilst the Commission was set up to suggest a scheme for the reorganisation of pigs and pig products and therefore the title of the publication is quite accurate, it should be noted that the Report deals only with bacon pigs and bacon, the commission finding that there was little prospect of a permanent profitable expansion of pork production

owing to the limitations of the market. The Report therefore aims at an expansion of bacon pig and bacon production in this country, neglecting entirely, for the present, the pork pig and fresh pork market. The objects being to develop a pig production expansionist policy, by offering a guaranteed market at the same time developing a stabilised bacon-curing industry. J.G.W.

Poultry, Guide for Organising Farmers' Co-operative Marketing Associations.
Bulletin No. 7.

Co-operative Marketing makes steady growth.
Bulletin No. 8.

Statistics of Farmers' Selling and Buying Associations, United States, 1863-1931.
Bulletin No. 9.

Co-operative Marketing of Farm Products.
Bulletin No. 10, Federal Farm Board, Washington D.C.

These publications of the Federal Farm Board are of interest to all concerned with agriculture in this country as a source of information of the type of work carried out and of its achievements. Both in this country and the United States the organised marketing of agriculural products is receiving considerable attention by the government departments concerned. In the latter country three important Acts dominate this control, the Agricultural Marketing Act, the Capper Volstead Act, and the Act Creating Division of Co-operative Marketing. These publications give a general idea of the method of attacking the problem in the United States and therefore give a fair basis for comparison with the methods adopted to solve a similar problem in this country.

Bulletin No. 7, on poultry, is a detailed statement of the legal requirements of Co-operative marketing associations in the United States together with an outline of the procedure necessary for the setting up of an organisation for the sale of poultry. It also includes a statement on the method of reorganising existing associations in order to permit them to take full advantage of concessions received under the more recent Acts. Legal forms and model rules of societies are included. The final appendix consists of a copy of the Capper Volstead Act.

Bulletin Nos. 8, 9 and 10 are mainly descriptive, covering a wide variety of commodity organisations which exist, although Bulletin No. 9 is mainly historical. J.G.W.

Scotland and Wales, Agricultural Co-operation in.
A Survey by the Horace Plunkett Foundation. Published by Routledge and Sons, Ltd.

This is the final volume of a series of surveys, undertaken by the Horace Plunkett Foundation, of Agricultural Co-operation in the British Isles. Treating both countries independently it follows the procedure adopted in the previous surveys, giving a short historical introduction followed by a survey by counties introducing a brief description of the activities and financial position of each individual society. There is also considerable descriptive matter on interesting experiments in agricultural co-operation for the marketing of miscellaneous farm products.

It is unfortunate that the report on the activities in Wales is not absolutely reliable and even errs badly in some respects.

J.G.W.

Wool Marketing.

ALVA H. BENTON. Bulletin No. 252, Agricultural Experiment Station, Fargo, North Dakota.

This is a brief survey of the general problem of wool marketing in the United States, but it contains a fairly detailed statement of the progress of the North Dakota Co-operative Wool Growers' Associations. There is a short discussion on the trend of sheep and wool production, together with a study of consumption in relation to the growth of population. Imports together with the effects of the tariffs and also the trend of consumption of the substitutionary products rayon, silk and cotton are discussed as an introduction to more important study of the factors which determine the market value of wool. These factors are dealt with on the basis of the system of grading in the United States giving an interesting explanation of the attempt to substitute the " blood " basis of grading by the " count " system. To those interested in the co-operative marketing of wool this is a full description of the origin, organisation, methods of operation and marketing costs of the co-operative organisation for the sale of wool in North Dakota commenced in 1920.

An excellent glossary of wool terms is appended which is of considerable value to those not acquainted with the technical terms of the wool market. J.G.W.

ANIMAL NUTRITION.

Abstractor:

R. O. DAVIES, M.Sc., University College, Aberystwyth.

Cellulose; The Mechanism of—Digestion in the Ruminant Organism. (iii) The action of cellulose-splitting bacteria on the fibre of certain typical feeding stuffs.

H. E. WOODMAN and J. STEWART. *J. Agr. Sci.*, 1932, 22, 527-47.

Results of the action of cellulose splitting bacteria on the fibre of a number of typical feeding stuffs are given. The fermentability of the fibre separated from a number of feeding stuffs shows that the fermentation coefficients are higher than the corresponding fibre digestion coefficients as determined in animal trials. The digestibility of the fibre in a crop is not merely influenced by the amount of ligno-cellulose which it contains, but is chiefly related to the intimacy of the association of the ligno-cellulose with the cellulose in the cell walls. R.O.D.

Chickens; The Relation of Calcium and Phosphorus to Growth and Rachitic Leg Weakness in

R. T. PARKHURST and M. R. MCMURRAY. *J. Agr. Sci.*, 1932, 22, 874-82.

Retarded growth and poor bone development resulted from feeding a ration in which 5 per cent. of maize meal had been replaced by 5 per cent. of ground limestone. The basal or no-limestone group confirms previous results indicating that ground limestone may have a depressing effect on growth. R.O.D.

Dairy Cows; Calcium and Phorphorus Assimilation by

H. B. Ellenburger, J. A. Newlander, C. H. Jones. *Proc. Amer. Soc. Animal Production*, January, 1932, 126-8.

Calcium and phorphorus balances were computed weekly on five cows extending over full lactation and gestation periods. Negative balances appear to be normal during the early part of the lactation and are compensated by rapid storage as lactation and gestation proceeds. The cows assimilated 42.9 per cent. calcium and 27.1 per cent. phosphorus when ensilage was fed. R.O.D.

Ewes; Importance of Preparatory Feeding before Lambing for Milk Yield of

R. Kellner. *Dissert. Breslau*, 1931 (Expt. Sta. Animal Breeding and Dairy Farming, Univ. Breslau).

Observations were made on thirty ewes in three groups. A considerable increase in milk yield was found in the ewes given preparatory feeding. R.O.D.

Grassland Management; Investigations into the Intensive System of.

S. J. Watson, W. S. Ferguson, J. Proctor. *J. Agr. Sci.*, 1932, 22, 235-90.

(VIII) The comparative digestibility and feeding value of fresh and artificially dried grass.

Drying grass in a band drier by heated air at an inlet temperature of 200°C. has not affected the digestibility of the various constituents, with the possible exception of crude protein which is slightly depressed. By means of a temperature of 600°C. the output of the drier is increased, but the digestibility of the final product is adversely affected.

(IX) The digestibility of artificially dried hay.

Hay of excellent quality and high digestibility has been made by a process of artificial drying in which a current of warm air is blown through the grass in a stack. The resultant product was of much greater feeding value than good meadow hay or seed hay, and was made at a season of the year when hay making conditions were poor.

(X) Mineral content of intensively treated pasture.

The mineral content of intensive pasture is equal to that of the best type of pasture produced by other systems of management, and superior to that of average good cultivated pasture in Great Britain.

(XI) The effect of nitrogen on the yield, composition and digestibility of grassland herbage.

The results of these experiments indicate the effect of nitrogen on the production of earlier grass, and on the production of an increased yield of dry matter and protein. They also indicate that nitrogen has effected a more uniform distribution of growth and a higher autumnal growth. The digestibility of the nitrogen treated herbage has been high throughout the season. R.O.D.

Maize Germ; The Influence of—on the Quality of Bacon.

C. Crowther. *J. Min. Agr.*, 1932, 39, 428-40.

Experiments are described which were carried out at various research centres to compare the relative merits of whole and " degermed " maize in pig feeding. Reliance was placed primarily upon inspection both of the fresh meat and the cured carcasses. The experiments are in substantial agreement in demonstrating that the removal of the germ from the maize tends towards the improvement of bacon quality. R.O.D.

Maize Meal; (Cooked)—The Value of—in the Nutrition of Swine.

H. E. WOODMAN and R. E. EVANS. *J. Agr. Sci.*, 1932, 22, 670-5.

Degermed maize meal (cooked) is equal, in respect of digestibility, to such highly digestible foods as tapioca flour and flaked maize, and is significantly superior to whole maize meal and barley meal. On account of its low oil content it should be capable of being employed liberally in the rations of porkers and baconers right up to date of slaughter, and in this respect, therefore, possesses an advantage over both whole maize meal and flaked maize. R.O.D.

Malt Coombs; The Value of—as a Feeding Stuff.

J. P. DREW and D. DEASY. *Irish J. of Agr.*, 31, 1932, 42-9.

Malt coombs and palm kernel cake, two foods of similar analysis, but differing considerably in price, are compared in equal quantities in feeding trials. The results indicate that

(*a*) Malt coombs and palm kernel cake are of about equal feeding value for calves and yearling cattle.

(*b*) Palm kernel cake is superior to malt coombs for fattening cattle, probably to the extent of about 10 per cent.

(*c*) For milk production, palm kernel cake is also somewhat better than malt coombs. R.O.D.

Mineral Requirements of Pregnant Sows.

R. E. EVANS. *J. Min. Agr.*, 1932, 39, 544-8.

A suitable mineral mixture for in-pig sows (not having access to good grazing) should contain chalk and common salt in proportion of four parts of the first to one part of the second. This should be fed at the rate of 1 oz. per head per day. During lactation, about 2¼ oz. of the mineral mixture would be required per head daily.

R.O.D.

Oats; The Value of—in the Nutrition of Swine.

H. E. WOODMAN, R. E. EVANS, and A. W. M. KITCHEN. *J. Agr. Sci.*, 1932, 22, 657-67.

The results of digestion trials show pronounced differences in the extent to which pigs are able to digest oats in varying degrees of fineness and emphasise the advantage of grinding oats as finely as possible for inclusion in pig ratios.

In two separate farm feeding trials it has been shown that neither the partial replacement of barley meal (lb. for lb.), nor the total replacement of middlings (also lb. for lb.) by farm ground oats exerted any significant disturbance of the rate of live weight increase, or the economy of food conversion, in the bacon pigs under experiment. R.O.D.

Pasture; Nutritive Value of. (VIII) The influence of intensive fertilising on the yield and composition of good permanent pasture.

H. E. WOODMAN and E. J. UNDERWOOD. *J. Agr. Sci.*, 1932, 22, 26-71.

This investigation was primarily designed to test the effect of periodic application of sulphate of ammonia on the yield and composition of good permanent pasture well supplied with reserves of lime, potash and phosphate. The results suggest that the improvement of yield brought about by the use of soluble nitrogen on permanent pasture of good quality may not during the first two seasons of its application be very considerable. Only when growth is very rapid, as in the early season, are the plants unable to secure supplies of nitrogen at a rate consistent with

their maximum capacity for building up new protein. At such a stage, therefore, the addition of readily available nitrogen to the soil is reflected in a stimulation of the rate of growth. The results suggest that a single large dressing of sulphate of ammonia might advantageously replace the small dressings applied periodically throughout the season.

The influence of manurial treatment on lime uptake in the herbage is of a striking character, the nitrogen treated herbage actually containing slightly less lime than the herbage not receiving sulphate of ammonia. R.O.D.

Pasture; Nutritive Value of. (IX) The influence of the intensity of grazing on the yield, composition and nutritive value of pasture herbage.

H. E. WOODMAN and D. B. NORMAN. *J. Agr. Sci.*, 1932, 22, 852-878.

The lengthening of the interval between successive cuts from a month to five weeks leads to a definite reduction in the digestibility of the herbage. Attention is called to the difficulty which a farmer might experience under a five weekly rotational close grazing system in securing the uniform grazing down of the huge growth of herbage which normally would be obtained during the flush period. To meet this difficulty it is suggested that (1) A portion of the pastures might be set aside for cutting instead of grazing. (2) The interval between successive close grazings might be shortened during the flush period and afterwards lengthened to five weeks again. R.O.D.

Pellet and Lick Feeding of Stock.

B. C. ASTON and J. LYONS. *New Zealand J. Agr.*, 1932, 44, 260-2.

The different methods of giving supplementary minerals to stock (1) by pellet, (2) by salt powder lick, and (3) by salt blocks, are compared. Pellet feeding is expensive but there is little wastage; salt powder lick is necessary when phosphates are used. Where phosphates are absent from the mineral supplement, salt blocks are advantageous.

R.O.D.

Pigs; Dried Sugar-Beet Pulp for.

T. S. WRIGHT. *J. Min. Agr.*, 1932, 39, 111-5.

Feeding experiments are described, carried out with Large Whites, of an average age of fifteen weeks and an average weight of 54 lbs. at the start. The feeding period covered a space of four months. The results indicate that dried sugar-beet pulp, when supplemented by a protein food, can be made an efficient substitute for sharps for fattening hogs, but should not form more than a fifth of the ration if looseness is to be avoided. To eliminate the possibility of digestive trouble, and to obtain the best returns, feeding should be carried out thrice daily where this food is included. It should be used with care if given to pigs under sixteen weeks of age. R.O.D.

Pig-Feeding; Minerals in.

C. CROWTHER and T. S. WRIGHT. *J. Min. Agr.*, 1932, 39, 201-7.

Different minerals were given to three lots of Large White pigs, each lot receiving the same basal ration. The average age of the pigs at the start was fifteen weeks, and the average weight 55 lbs. Fattening lasted over a space of four and a half months. It is concluded that

the only mineral supplements required by pigs on a diet of cereals, wheat offals and soya meal are lime and salt. The amount of salt must be carefully rationed. R.O.D.

Pig-Feeding; The Place of Cod-Liver Oil in.

A. H. Blissett. *Scot. J. Agr.*, 1932, 15, 426-29.

It is concluded from these experiments that even when fed on a well balanced ration, pigs reared during the winter months are liable to suffer from bone disease, and a small quantity of cod liver oil will help to correct this. R.O.D.

Pig Rations; Lentil Meal as a Protein Supplement in.

A. W. M. Kitchin. *Scot. J. Agr.*, 1932, 15, 59-62.

In these experiments ten parts of lentil meal in conjunction with a 1 per cent. mineral supplement of three parts ground limestone and one part salt were used to displace five parts fish meal in the rations of fattening pigs without any decrease in live weight gain and with a considerable reduction in feeding cost. R.O.D.

Pig Feeding; Use and Value of Barley Meal, Rye Meal and Molassed Rye Meal in.

F. Honcamp. *Tierernährung*, 1932, 4, 1-42.

The general conclusions ~~from these~~ co-operative experiments carried out with 228 pigs are quite favourable to the use of rye, provided that the average amount given over the fattening period does not exceed 2 kg. per head per day. Greatly improved results were obtained when 10 per cent. of molasses were mixed with the rye meal. For farm practice it is recommended that in meal feeding rye should not form more than one half of the total, whilst where potatoes are being fed the supplement of rye meal should not exceed an average of about 1 kg. over the whole fattening period. If it is desired to feed rye meal more liberally it should be mixed with 10 per cent. of raw sugar or molasses. R.O.D.

Poultry; Mineral Balance Studies on.

R. H. Common. *J. Agr. Sci.*, 1932, 22, 576-93.

From the results of calcium and phosphorus balances on laying pullets, it is shown that the pullets showed a diminution of the calcium and phosphorus in their droppings over a period of about two to three weeks before laying, and a correspondingly increased retention of these elements. R.O.D.

Sheep; The Effect of Lime and Cod Liver Oil on—fed on a Calcium deficient Ration.

D. W. Auchinachie and A. H. H. Fraser. *J. Agr. Sci.*, 1932, 22, 560-75.

It is shown that lime and cod liver oil in combination had a greater beneficial effect on sheep kept indoors than either lime or cod liver oil alone. In order to obtain normal calcium metabolism two factors are required: (1) An adequate supply of lime in the ration. (2) A factor necessary for utilisation of the lime fed.

From the results of this experiment it appears that this factor is supplied by cod liver oil and summer sunlight, but not sufficiently by winter sunlight. R.O.D.

Sheep Grazings; Restoring the Fertility of Scottish.

J. B. ORR and A. H. H. FRASER. *Trans. High. and Agr. Soc., Scotland.* 1932, 44, 64-85.

Two years experimental work on an Argyllshire sheep farm are described, where dietary supplements were fed to different groups of sheep on the same farm under natural conditions. It is suggested that supplementary feeding on hill grazings will eventually restore their fertility, and that the cost of feeding may be immediately recovered in the increased production of the sheep stock. R.O.D.

Vitamin; The Fat Soluble—Requirements of Cattle and Pigs during Growth, with Remarks on some other Questions as to the Vitamin Problem in Cattle and Pig Feeding.

H. ISAACHSEN. *J. Agr. Sci.*, 1932, 22, 460-84.

These experiments indicate that calves, heifers and growing pigs will not suffer from deficiencies of fat soluble vitamins when fed upon a mixture of varied, natural food stuffs including yellow maize for pigs plus common salt and the necessary amount of limestone. Pigs are more likely to suffer from disordered mineral metabolism due to a deficiency of minerals in the feed than they are from feeds generally considered poor in the fat soluble factors. R.O.D.

CROPS AND PLANT BREEDING.

Abstractor:

T. J. JENKIN, M.Sc., Welsh Plant Breeding Station, Aberystwyth.

Y Tir a'i Gynnyrch.

R. ALUN ROBERTS. td. 142. Pris 2s. 6ch.

Dr. R. Alun Roberts needs no formal introduction to Welsh readers or to readers of Welsh, since his articles are already well-known and appreciated. Since he is, and has been for several years, in charge of the Department of Agricultural Botany at the University College of North Wales, Bangor, and at the same time has kept in the closest touch with farmers and farming, he is particularly well qualified to write upon the subject he has taken in hand.

The present volume is the tenth in the series " Cyfres y Brifysgol a'r Werin ", published by the Press Board of the University of Wales. A brief outline of the history of agriculture in Wales, sufficient to form a background to a dissertation on the land and its produce, is given as an introductory chapter. This is followed by a discussion of the inter-relationship of the plant (or crop) and the soil, while in the third, plant growth and its implications is described.

The remaining chapters deal specifically with the individual crops —grassland (including hay), cereals, roots and leguminous plants. Each crop is dealt with from the practical standpoint and the whole book is designed for the immediate benefit of the farmer.

In a treatise of this kind, it is inevitable that many technical terms must be introduced, but this difficulty is overcome by the provision of a glossary in which the English equivalents of the Welsh terms adopted are given. A useful but not very detailed index is also added.

The volume is entirely worthy of its author and of the series to which it belongs, since it is readable, reliable in the information it conveys, and covers those points which are of direct and immediate interest to the farmer.

The introduction of Welsh names for the various herbage plants might seem to be unnecessary or even undesirable, but it should be borne in mind that even to-day farmers are not as familiar with the English names as they are sometimes assumed to be. It is also often forgotten that the standardised English names are mainly artificial and date only from the middle of the eighteenth century, while their Welsh equivalents were available early in the nineteenth. It is to be regretted, however, that where technical terms or unfamiliar words were first introduced in the book, a footnote directing the reader's attention to the glossary has not been provided at the bottom of the page. This glossary is not as comprehensive as it might have been, but Dr. Roberts obviously did not realise that such words as " Cemegwr " and " crawcwellt " would be unfamiliar to many readers. The book makes delightful reading for the man who can take it more or less in his stride, but may it be suggested that even at the cost of marring its fine literary flavour the use of words which are only familiar within a limited area might have been supplemented by their equivalents in brackets. Such words as " blewgeirch ', " myllt ", " suntur ", " codau " (for nodules), and, strange as it may seem, even " barrug " and " pryfed genwair " are quite unfamiliar to the man of Dyfed, who, on the other hand, would certainly use " yr ail lin " in preference to " yr ail hatsied ".

At times also, literary composition appears to lead to some obscurity. Thus, the method of seed production in grasses—" bwrw had "—might have been better explained, while two different passages give the erroneous impression that indigenous grasses come into flower earlier than their commercial counterparts.

Fortunately the statement (regretfully made) that " Hen Gymro " wheat has disappeared might have been omitted since it is still considerably grown in parts of Cardiganshire and Carmarthenshire.

Since a brief statement is made concerning old oat varieties in Wales, the old " Ceirch-du-bach " might well have been included. However recent the introduction of this variety into south-west Wales may have been, it was certainly well known far in advance of Tartarian, and the latter, at least in some districts, completely failed to supplant it. Much of the former " Ceirch-du-bach " area is now, however, under Radnorshire Sprig—another variety, whatever its origin, to which allusion might have been made. While on this subject, it may be added that a thin sprinkling of vetches was often found in " Ceirch-du-bach ", a fact which possibly made a considerable improvement in the crop for fodder purposes.

The present-day Welsh farmer does not escape entirely unscathed, but he will be the first to realise that a few scattered sarcastic allusions are the expression of an intense desire to see the farms of Wales again wearing that prosperous appearance which personal devotion to the land and its crops alone can give.

The apparent defects which are noted above, although they call for brief mention in a review, are actually very trifling in comparison with the real merit of the work as a whole, and the book is certainly one that

every Welsh-reading farmer should possess, read and ponder over in order that he may add substantially to his own pleasure and profit.

For those who wish to pursue the subject further, extremely useful notes on books and periodicals are given. T.J.J.

HORTICULTURE.

Abstractor:

W. H. BROADBENT, Welsh Department, Ministry of Agriculture.

The H.E.A. Year Book, 1932.

The Annual Publication of the Horticultural Education Association, Royal 8vo., 92 pp., 3/6, post free. Published by the Horticultural Education Association, Hon. Editor, R. T. PEARL, B.Sc., A.R.C.S., D.I.C., South-Eastern Agricultural College, Wye, Kent, December, 1932.

This is an excellent publication which, as stated by the editor, " ought to do much to enhance the prestige of the Association ". A glance at the contents shows a comprehensive list of articles oy men who are engaged in various branches of horticultural education. The contributors include Mr. H. V. Taylor, who deals with the effect on commercial horticulture of the imposition of duties on imported produce. Dr. W. F. Bewley writes on " Some recent developments in relation to Glasshouse Crops: the practical results of soil experiments, and the methods of controlling certain plant diseases are given. Mr. H. W. Abbiss gives an account of " Commercial Horticulture in Cornwall ". Mr. D. Boyes treats on the subject of Vegetable Breeding ": the difficulties encountered in the breeding of Brassicae are mentioned, and an interesting story of the raising of new and promising varieties of Brussels sprouts is related.

In addition, there is a number of informative articles by other eminent workers, but the above will suffice to indicate the scope and importance of the subjects dealt with, and to make it apparent that the book should be in the hands of every person who is interested in problems affecting horticulture. W.H.B.

LIVE STOCK.

Abstractors:

Professor R. G. WHITE, M.Sc., University College, Bangor; A. D. BUCHANAN SMITH, M.A., B.Sc., M.S.A., F.R.S.E., Department of Animal Genetics, University of Edinburgh; T. J. JENKIN, M.Sc., Welsh Plant Breeding Station, Aberystwyth.

Gestation Period of Holstein-Fresian Cows; A study of the.

J. C. KNOTT. *J. Dairy Sci.*, 1932, Vol. 15, No. 2, pp. 87-97.

The data used in this study were obtained from three pedigree Holstein-Friesian herds in the state of Washington. The figures are based on 2,910 gestation periods. Seventy-eight of the animals included

were Grade Holsteins. Eighty-six cases of twins were born and were considered separately in the presentation of the data. The length was found to vary from 262 to 296 days. Seventy-five per cent. of the calves were dropped from 275-285 days inclusive. Only 1.7 per cent. were carried for periods shorter than 270 and 2.7 per cent. for periods longer than 290 days. Male calves were carried on an average one day longer than female calves. As the age of the dams increases from two to six years the length of the gestation period increases by approximately one to one and a half days. After six years there seemed to be a tendency for the gestation periods to become slightly shorter.

The gestation periods of calves sired by some bulls were definitely higher or lower than the average, indicating by their uniform divergence from the mean the possibility of paternal influence. The least variation in the length of gestation observed for twenty-nine cows that had each produced six or more calves was six days. The greatest was twenty days. Some cows were quite uniform as to the length of their gestation periods while others varied widely. Eleven exceptionally high producing cows were carried in dam an average of 278 days, or about one and one-half days less than the average for all females. The periods varied from 262 to 289 days. In comparing the gestation periods of the above cows with the gestation periods of the calves they produced, it was found that four of the eleven cases showed a decided tendency for the calves of a cow to have gestation periods similar in length to her own.

A.D.B.S.

Cattle Classes in the Carcase Competition of the Smithfield Club, 1895-1929.

E. J. Roberts. *J.R.A.S.E.*, 1931, Vol. 92,

This account follows a similar analysis of the Sheep Classes in the same competition which was published in the *J.R.A.S.E.* for 1930, and was noticed in the last volume of this Journal. Again the results are of special interest to Welsh breeders because the Welsh breed has figured much more prominently in the Carcase competition than many of the breeds better known to the outside world. The exhibits have been mostly Cross-breds, Aberdeen Angus, Galloway and Welsh. Taking the period as a whole, Cross-breds, the type most numerously represented, have gained most first prizes, but in the last ten years Galloways have won most of the championship and first prizes in classes other than the " baby beef " class. In the latter class an Aberdeen Angus-Shorthorn cross has been the most successful. Welsh cattle won the first prize in the old bullock class on five occasions and in the young bullock class at three shows.

As in the case of sheep, the carcases exhibited in recent years have been of less weight than those in the earlier years discussed, but the reduction—8 per cent.—is much less than in the case of sheep, where the reduction was from 20 per cent. to 30 per cent. In the ten years ended 1930 the first prize carcases averaged 801 lb. for steers under two years, 916 lb. for steers between two and three years, and 785 lb. for heifers under three years. The greatest reduction in the size of carcases took place before 1900. The proportion of carcase to live weight from 1920 to 1930 varied between 68.2 and 68.9 except in the baby beef class, where it averaged 60.8. The proportion of carcase was lower in recent years than in the earlier years. It is interesting to note the difference —about 20 per cent.—between the live weight of animals shown in the

"live" classes of the show and the weights of the corresponding animals shown in the carcase class. The difference is presumably due to either excessive fatness or size of the former, and raises the general question of the utility of the ordinary fat stock show. There can be no doubt regarding the great value of the carcase competition. R.G.W.

Dentition of the Pig.

O. CHARNOCK BRADLEY. *Trans Highland and Agr. Soc. of Scotland*, 1932.

An examination of 670 pigs under one year old showed great variation in the age at which teeth appeared. The following were the periods of eruption of five lower teeth:—

First true molar. From 15 5-7 to 26 3-7 weeks, *i.e.*, a range of nearly eleven weeks.

First premolar. From sixteen to forty-two weeks, and frequently absent altogether. Its eruption is therefore held to be of no value as an indication of age.

Third, or Corner Incisor. From 27 1-7 to 40 4-7 weeks, *i.e.*, a range of more than thirteen weeks.

Canine or Tusk. From thirty-four to fifty-two weeks (probably more).

Second true molar. From 40 3-7 weeks to 49 weeks.

It is therefore concluded that it is impossible to ascertain the age of pigs with any satisfactory degree of certainty from the state of the teeth—at any rate up to twelve months. This finding, which conflicts with that of other investigators, is obviously of importance both to breeders and to societies which frequently lay down regulations regarding dentition for animals exhibited at shows. R.G.W.

Fat-Globule Size in Milk; A Study of the.

M. H. CAMPBELL. *Univ. Vermont Agr. Exp. Sta. Bull.*, 1932, 341.

This is a complete and painstaking review of the whole subject which includes some useful additional observations which have been made by the author.

Environmental factors were found to affect the size of the fat-globules in milk. Injury, sickness and sudden changes of condition produced a marked increase in the fat-globule size. Changes of feed in some cases caused an increase in size and in some reduction, while in others it had no apparent effect. Feeding of grain as compared to grass or the substitution of silage were without effect.

The fat globules are usually largest during the first two weeks of the lactation with the most rapid rate of decline occurring during the next two months. Thereafter the decline of the rate in size is slow but usually continuous to the end of the normal lactation period.

From the evidence available, there is no doubt that the size of the fat globule is primarily conditioned by heredity, and a number of factors appear to be involved in its transmission.

There is a significant difference between the means of the Guernseys and Holsteins and between the Guernseys and certain cross cattle whose milk was also analysed in this respect. A.D.B.S.

Heat Coagulation of Milk. 1: Variations in the Compositions, Heat Stability, and other Tests of Milks from four Cows during the Lactation Period.

GEORGE E. HOLM, B. H. WEBB, and E. F. DEYSHER. *J. Dairy Sci.*, 1932,, Vol. 15, No. 4, pp. 331-43.

The problem of the coagulation of milk by heat is an important one, and one about which we may expect to hear more in the near

future. Although the present authors worked on the milk of only four cows, they found that each of the individual milks retained fairly constant values in many of the tests, and that each value was characteristic for each cow.

Further investigation would appear likely to show that there is a genetic origin for this important difference. A.D.B.S.

Inheritance of Hernia.

T. R. Warren and F. W. Atkeson. *J. Hered.*, 1931, Vol. 22, No. 11, pp. 345-52.

Several calves with umbilical hernia were noticed in two herds of pure bred Holstein-Fresian cattle in which the same bull had been used. This made the authors examine the whole subject, and they state that there is evidence as to the inheritance of hernia in the human being, in the pig, horse, dog, sheep and goat.

The data presented in this paper were calculated from three herds which contained animals related to the sire already mentioned. Twenty-one herniated calves were observed, all of common breeding. The type of the hernia is closely described, but as to the mode of its inheritance the authors state that they are not yet in a position to draw definite conclusions. However, it appears to be inherited in a relatively simple Mendelian manner which does not appear to be transmitted in a sex linked manner, though there is reason to believe that it is conditioned by sex. The writers state that umbilical hernia cannot be a serious problem in the breeding of dairy cattle or it would have been more universally present and recognised than seems to be the case. On the whole, the evidence would show that hernia behaves as a dominant character in males but that for females the mode of its inheritance is questionable. A.D.B.S.

Inheritance of Milking Capacity.

Karl Madsen. *Nature*, Jan. 30, 1932, pp. 165, 166.

With a view to studying the importance of different bulls as measured by the production of their progeny, the author correlated the yields of the daughters of a large number of bulls of the Red Danish breed to the yields of their dams and grandams and to the yields of the daughters of their sires and grandsires. He has worked with a fairly large number of animals. In most cases there were over five hundred bulls correlated to a particular ancestor, and the average number of daughters to each bull was eighteen. The yields were corrected for age, etc. He finds a highly significant difference between the correlation figures of the bulls to the yields of their grandams, that to the paternal grandam being practically nil, while that to the maternal grandam is significant. This is in distinction to the correlation of the yields of cows to their paternal grandams, which are as high as to their maternal grandams, but it is in accord with the view that some of the factors governing the inheritance of milking capacity are transmitted in a sex-linked manner. A.D.B.S.

Inheritance of Whorls in the Hair of Swine.

J. E. Nordby. *J. Hered.*, 1932, Vol. 23, No. 10, pp. 397-404.

The whorl in the hair of a pig is in this country often called a " rose ". If a pig has it, as often as not it will be found on the rump along the spinal column. It may, however, occur on the neck, the loin, the under line or the head of the pig.

For some time it has been recognised that this rose is definitely of a hereditary nature, but the mode of inheritance had not been properly "taped". The point which has proved a stumbling block to many investigators is that, while pigs without a rose can give progeny with a rose, it does not always hold good that two pigs each with a rose mated together will produce progeny all of which exhibit a rose. Dr. Nordby explains this phenomen on a basis of the effect of two dominant pairs of factors. Each of these factors must be present in the heterozygous or the homozygous condition before the whorls are produced.

In order to eliminate this defect, the writer states that it is imperative to discard both the sire and the dam of the pigs that have whorls. When a smooth haired boar mated to a smooth haired sow sires pigs with whorls, the boar is often given the blame for producing the whorls. As a matter of fact he is probably not more responsible than the sow, quite irrespective of the fact that these sows when mated to another boar might never have given any progeny with whorls. The writer strongly advises discarding from the breeding herd all the sows and most certainly all boars that have got whorls. He also states that it is almost as important to remove with equal diligence sows and boars with smooth hair that have produced progeny with the rose.

A.D.B.S.

Malformation in Icelandic Sheep.

ZUPHONIASSON. *Nordi Jordbruksforsk,* 1930, No. 4, pp 327-30. *Abs. in Quart. Bull.*, Vol. 2, No. 5, pp. 118, 119 of the Imperial Bureau of Animal Genetics.

The writer describes two types of malformations. In the first the skull is large but the upper jaw is compressed, the nostrils lying close to the mouth, while the lower jaw is always shorter than the upper. The fleece is short and straight and a naked strip runs across the belly from the chest, and this is usually accompanied by a small hernia. The lambs are usually born alive but cannot stand up owing to the bending of the feet and can only crawl on their knees. They die soon after birth. This defect has been traced to a prize ram whose daughters were mated back to him.

The second condition consists of paralysis of the new born lambs. They drag their hind legs and hardly swallow, and have a look of imbecility. By careful management they can be kept alive. A similar condition may be due to deficiency in nutrition, but that described here appears to be clearly due to a hereditary factor. Both causes appear to be inherited as simple recessives. A.D.B.S.

Milk Secretion; The Influence of Age on First Calving on.

C. W. TURNER. *Miss. Res. Bull.*, 1932, 164.

This is in many ways a confirmation of the work which M'Candlish did regarding the most economic age at which to calve Ayrshire heifers. It will be recalled that M'Candlish found this to be two years and six months. Dr. Turner's study extends over four breeds, Ayrshires, Jerseys, Guernseys and Holsteins. He points out that the increase in milk and fat production in heifers calving after thirty months of age in all these breeds is practically negligible. In other words, every heifer remaining unproductive at thirty months of age or over is being maintained at a loss not only of the maintenance cost and of the investment of the animal but in the productive life also. Yet he shows that 48 per cent. of the Ayrshire cows calved after thirty months of age.

This study clearly reveals a significant increase in milk and fat production if calving was delayed till the animal reached thirty months of age. The results seem to confirm the theory that this increase in milk and fat production owing to the delay in the time of first calving is due to growth in body weight. Increase in yearly fat production is about 20 lbs. per 100 lbs. increase in body weight. The youngest heifer included was a Jersey which calved at thirteen months. The youngest Guernsey calved at sixteen, while the youngest Ayrshire and Holstein Friesian calved at seventeen months. As to whether, under certain circumstances, it would be advantageous for heifers to calve down for their first time at under thirty months of age depends to a great extent upon environmental conditions. As it is, the difference in age at first calving between the four breeds shows very little variation. What stands out clearly is that nothing could be gained by delaying the calving of dairy heifers beyond thirty months. A.D.B.S.

Mule; A Fertile.

ERNEST WARREN. *Nature*, Jan. 23, 1932, p. 130.

It has now been fairly well established that there are occasional mules which are fertile, and the few cases known would seem to show that a fertile mule may produce offspring by either a stallion or by a jack. Here is reported an indisputable case of fertility in a mare mule. Her first foal born in 1924 was probably by a stallion and was practically indistinguishable from a pure horse. After an interval of seven years, although during that period she had been repeatedly served, she foaled again in November, 1931. In the present foal the characters of the horse appear to be remarkably prepotent over those of the mule just as was reported in the case of the first foal. A.D.B.S.

Multiple Births in Schleswig-Holstein; Herd-Book Records.

T. MARWITZ. Dissertation, Leipzig (Zuchtungskunde), 1930, Vol. vii, pp. 62, 63.

The author analysed the herd-books of the Black Pied, Red Pied, Angeln and Shorthorn cattle in Schleswig-Holstein. The average percentage of twinning, irrespective of breeds, was found to be 0.52.

The Shorthorns gave the highest percentage of twins, and the Pied breeds higher than the Angeln. The difference between the Red and the Black breeds is not significant. The author sees indication of inheritance of twinning in that twin births recur in the same cow or the same family. There does not appear to be any influence on the part of the sire on inheritance of twinning. A.D.B.S.

Sex Ratio and Multiple Births in Cattle.

IVAR JOHANSSON, Ultuna Agricultural College, Uppsala, Sweden. *Zeit. f. Zucht. Reihe B. Tier und Zucht. Einschliesslich Tierernahrung,* Band XXIV, Heft 2, pp. 183-268.

The frequency of multiple births is to a great extent a breeding characteristic. Twins are commoner amongst the Swedish Friesians than among the red and white cattle or the Swedish Landrace. They would also appear to be commoner in dairy than in beef breeds.

The age of the mother has a pronounced effect on the tendency to multiple births which increases up to the age of about eight or nine years. The age of the bull at the time of mating seems to be of no importance in this respect.

In the Swedish and Finnish breeds of cattle there is a significant variation in the frequency of multiple births. Two yearly maxima are observed; one in the months of June and July and another in December and January, the second being less pronounced than the first. The seasonal variation in twinning is held to be due principally to climatic conditions which affect the number of ova which the cow may shed.

The writer comes to the conclusion that the quality of the feed affects the fertility of the cows but has very little to do with the question of twinning, whereas the quantity of the feed may, on the other hand, have a certain influence on multiple births. Several instances are given which show the inheritance of twinning.

A.D.B.S.

Soft Curd Milk.

R. L. Hill. *Bull. 227, Utah Agr. Exp. Sta.*, 1931.

Dr. Hill is the human nutritionist at the Utah Agricultural Experiment Station. Having formed the opinion that the softness of the curd was a prime factor in the digestibility of milk by babies, he proceeded to investigate this characteristic so far as it concerned individual cows. In this paper is described the methods which he employed. Dr. Hill found a wide variation in the curd character of milk from different cows from the same breed as well as certain differences between breeds. He found that the milk produced during the first month of a lactation has usually an abnormally hard curd but that this does not apply to the colostrum. The hard curd remains for a period of a little over a month. At the same time Dr. Hill does not imply that a soft curd cow necessarily gives hard curd milk during this period. He thinks that the milk secreted by such a cow would be higher in its curd function immediately after calving than during the remainder of the lactation period. Towards the end of the lactation the curd again becomes somewhat harder, though in a few instances it becomes softer.

But all environmental causes appear to be overshadowed by the genetic. Dr. Hill ran the curd test on the dairy cows at his experimental station for over a period of ten years. In every case it appeared to be an individual characteristic of the cow. Except for very sudden changes in the diet, the curd character of the milk is independent of the nature of the feed given. Neither was soft curd associated with low butter fat content, though the writer states that milk with a curd test of less than 20 grams (which is extraordinarily low) is usually decidedly low in fat content. Although on the contrary he found some cows giving as high as 6 per cent. butter fat which had a curd test below this point.

The evidence which Dr. Hill puts forward in this bulletin so impressed the breeders of Ayrshires that steps have been taken in the United States for making soft curd tests on a large scale. The results of these are to be found in the Ayrshire Digest for July and August, 1932, and in the Ayrshire Journal for September, 1932. In the latter periodical is to be found a comparison of the curd tension of the Ayrshire with other dairy herds. The Ayrshires included 915 individual cows in twenty-five herds, and the tests were conducted at the Standard Fat Testing Laboratory of the Baird Laboratories. The evidence would indicate that the Ayrshire breed contained a larger proportion of soft curd cows than did any of the other breeds tested at the Utah Experimental Station.

Dr. Hill concludes his bulletin by citing case histories of babies fed on soft curd milk. In two cases the baby was reared from birth exclusively on soft curd milk. It would appear as though this new grade of milk were likely to be of considerable importance, and already arrangements have been made in various parts of the United States for the sale of this particular product. The value of soft curd milk, Dr. Hill states, is not confined to infant nutrition alone, in cases of adult indigestion and gastric ulcers it has been used with remarkable results.

A.D.B.S.

Superfoetation in the Ewe; A Case of.

C. E. Aubel. *J. Hered.*, Vol. 23, No. 4, 1932, pp. 159, 160.

Cases of superfoetation in mares, cows, and sows have been frequently reported. In America few cases in the ewe have been noted. The writer gives particulars of a Shropshire ewe which produced a lamb on December 25th, 1930, another on May 5th, 1931, and two more on July 25th, 1931. All the lambs were normal. The last two lambings are clear evidence that the ewe was successfully mated when already in lamb. It is impossible to be certain whether the birth on December 25th and May 5th, at an interval of 131 days, represents another case of superfoetation or not.

R.G.W.

Udder Abnormality in Cattle; An Inherited.

Edwin E. Heizer. *J. Hered.*, Vol. 23, No. 3, 1932, pp. 111-4.

This abnormality has been reported from Ohio State University. On one side the udder of the cow is normal, but on the other side, usually the left, only one quarter with one teat is present. It is very objectionable and materially affects the usefulness of the cows. Such animals are difficult to milk and consequently the owners have used them for nursing calves. The left half of the udder is nearly as large and almost the same shape as the right half. The character has been found only in Guernsey cattle, but there is reason to believe that Dr. C. W. Turner, of Missouri, has also found it in the Hereford breed. All the evidence points towards its being inherited as a simple Mendelian recessive. The factor is of great economic importance to breeders in dairy cattle as, due to its recessive nature, its presence may be disseminated throughout an entire herd before an abnormal individual appears. Special attention on this point should be paid to the selection of bulls. The writer recommends that the best way to stamp out this undesirable factor would be for the breed associations to insert a clause in their registration requirements which would prevent registration of individuals, either male or female, which did not show normal udder or rudimentary development.

It is certainly a point against which breeders in this country must be on their guard.

A.D.B.S.

Vitamin A Content of the Milk of Holstein, Ayrshire, Jersey and Guernsey Cows.

H. P. Davis and I. L. Hathaway. *Agr. Exp. Sta. Nebraska Res. Bul.*, 1931, 54.

This investigation appears to have been conducted in an adequate manner. The Vitamin A content of the milk was assessed by comparing the growth produced by 560 rats, receiving milk from the Holstein, Ayrshire, Jersey and Guernsey breeds as their only source of Vitamin A

Negative controls received the Vitamin A supplement of free diet and positive controls a one-tenth of a cubic centimeter of cod liver oil daily. The results showed some slight irregularity, but when these differences were considered in view of the individual variation of the experimental animals, they appeared negligible. This conclusion was substantiated by a statistical examination of the data. The authors find that under the conditions of their experiments, the difference in the Vitamin A content of milk from these four breeds of cattle is insignificant. A.D.B.S.

Yearly Feed Cost and Butterfat Production in Dairy Cattle; The Functional Relation of.

R. E. HODGSON. 1932, *J. Dairy Sci.*, Vol. 15, No. 3, pp. 212-9.

The yearly butterfat production of dairy cows is regulated and influenced by a number of hereditary and physical factors. The ability of an animal to produce a large amount of butterfat in a year is inherited but unless the physical factors involved are adequately provided, maximum production cannot prevail. The purpose of the present paper is to determine the extent to which it paid to give the cows additional feed.

The writers obtained a high correlation of practically .6 between increased yield and increased cost of production. In other words, the cost of producing 1 lb. of butterfat decreased as production increased.

A.D.B.S.

Magu a Phorthi Anifeiliaid.

J. JONES GRIFFITH, td. 111. Pris 2s. 6ch.

The only regret that one feels after reading this volume is that Professor Griffith has not hitherto contributed more extensively to Welsh (and English) literature, since his capacity for lucid exposition, so well known to those who have heard him in the lecture room, is here seen to be equally demonstrated in the written word. With this, we find in this fourteenth volume published by the Press Board of the University of Wales, an intensely sympathetic attitude towards the Welsh farmer in these difficult times, and a full understanding of the farmer's standpoint. Indeed, we would almost consider that at certain points his candour tends to be excessive, particularly where he admits that experience has taught the farmer things which are obviously true but for which he can offer no satisfactory explanation. This attitude can easily be explained. Professor Griffith has behind him that early training as a farmer that leads inevitably to it. He is also the true scientist who is not afraid to admit that things which cannot be explained may yet be perfectly true.

No apology was required for including the two introductory chapters, the one dealing with the principles of breeding and the other with the principles of feeding. Both these are essential in order that the full significance of what follows may be clearly understood. In the remaining chapters the author deals separately with cattle, sheep, horses and pigs, and shows how those principles explained in the introductory chapters have a direct application to the practical breeding, feeding and management of livestock. A useful and comprehensive bibliography is added, together with a glossary of somewhat unfamiliar terms.

As a naturalised Mid-Walian, with a Lleyn and Eifionydd background and a close association with Dyfed, Professor Griffith has succeeded wonderfully in the adoption of a style and vocabulary which

rarely lead to verbal difficulties or obscurity, and quite possibly he may have, on occasion, chosen the word which is more familiar to the South-Walian than to others. In most cases, however, words which may be strange to a section of his readers are explained either in the glossary or by means of equivalents in brackets. Here again it is to be regretted that a footnote has not been inserted on that first page where a word that is explained in the glossary occurs, directing the reader's attention to it. Very wisely, the author has taken pains, in the difficult matter of the descriptive nomenclature of sheep, to give a full explanation in the text, so that the reader then knows exactly to what class of sheep he refers at every point.

Misprints are few and, as a rule, quite unimportant, but unfortunately a serious mistake has been made on p. 17. The uninitiated might easily accept the word " ymwanha " as " ymwahana "—a word which gives an entirely different significance to this important paragraph. The exact meaning of one paragraph on p. 37 seems to be obscure, but the book as a whole is remarkably easy to read despite the introduction of many terms which are unfamiliar to Welsh readers. In particular, the successful treatment of the principles of breeding in the first chapter must be especially mentioned since here Professor Griffith is breaking new ground. The words used show very clearly how well the Welsh language can meet the occasion when new terms are being introduced. Some, such as " genoteipaidd " are both ugly and cumbersome, but not more so than their English equivalents.

The inclusion of a section on Galton's Law is justified on the ground that it must impress upon the reader that it is not only the immediate parents which must be considered in a breeding policy, although in its details it still remains more of a theory than an established law.

A trifling point is the need for even a greater measure of uniformity of words and terms in different volumes of the same series. Dr. Alun Roberts, for instance, in " Y tir a'i gynnyrch " uses the word " pupys " whereas that used by Professor Griffiths is " ffacbys ". Again the former refers to " blawd yr India ", while the latter, in referring to the unground grain, uses " India-corn ".

If the two volumes of " Cyfres y Brifysgol a'r Werin " here briefly reviewed meet with anything like the acceptance they obviously deserve, it may confidently be expected that the farmer who, in his distress has turned to barbed-wire, cattle-dealing and bargain-hunting, may once more be found taking pride in his well-cared-for fields and livestock.

T.J.J.

PLANT PATHOLOGY.

Abstractor:
T. Whitehead, Ph.D., M.Sc., A.R.C.Sc., University College, Bangor.

American Gooseberry Mildew; Control of—in Northern Ireland.
A. E. Muskett and E. Turner. *J. Min. Agr. North. Ireland*, 1931, iii.

After eight seasons' work the conclusion is reached that this disease can be controlled in a satisfactory way by two applications in summer of (1) ammonium polysulphide spray, 1 in 200 plus 4 lb. soft soap per 100 galls. of spray (costing 15s. 6d. per 100 mature bushes); or (2) a good ground sulphur dust or flowers of sulphur at the rate of 20 lb. per

100 bushes (costing 12s. per 100 bushes); or (3) lime-sulphur, 1 in 100 plus 1 gall. skimmed milk or 4 galls. flour paste per 100 galls. of spray (costing 11s. per 100 bushes). Amber and other varieties liable to sulphur injury should be sprayed in February with caustic soda (2 lb. per 10 galls.) plus 1 gall. skimmed milk per 100 galls. of spray (costing 19s. 6d. per 100 bushes). T.W.

Apple Scab control in the Bristol Province; Field Trials, 1930.
R. W. MARSH. *J. Pom. and Hort. Sci.*, 1931, ix, No. 1.

Excellent control of apple scab was obtained when the trees were sprayed at the " green flower ", " pink ", and " petal fall " stages, though less effective control resulted when the first spray was applied before the green flower stage. The exposure of vaselined slides demonstrated that the sole source of infection in the experiments during April and May, 1930, consisted in the pustules present on the wood. Additional evidence pointing to the importance of scabbed wood as a source of primary infection in the spring was frequently obtained in 1930 by noting the proximity of the leaves first scabbed to the active scab pustules on the twigs. The writer considers that the American view of the importance of over-wintered leaves in initiating attack in spring should not be accepted without further examination as necessarily applying equally to Great Britain. T.W.

Apple Scab and Apple Mildew; Further studies at East Malling.
M. H. MOORE. *J. Pom. and Hort. Sci.*, 1932, x, No. 4.

The conclusions in regard to scab control on Cox's Orange Pippin confirm, in the main, previous findings. Although Bordeaux mixture proved the best " scabicide " it showed certain economic disadvantages in the tendency to cause spray injury and its inefficacy against red spider and mildew. Lime-sulphur gave very good control of scab, mildew and red spider, especially when applied three times—once before and twice after blossoming. It caused fruit-drop only when used, post blossom only, at 1 in 100 strength. In spite of fruit-drop, these trees did not suffer reduction in picked crop below that on comparable Bordeaux-sprayed or control trees. Where a pre-blossom lime-sulphur spray was used with or without post-blossom applications, much greater crops were picked than from any other comparable trees, as in other years. It is also shown that, in the main, certain rootstocks promote greater scab-susceptibility than others in Cox's, but that such influence is governed to some extent by seasonal factors.

The results of spraying for apple mildew control on Cox's Orange Pippin and Belle de Boskoop in 1929 and 1930 are discussed. Lime-sulphur was shown to be the most effective spray of those tested on the former variety, Bordeaux mixture and colloidal sulphur proving rather unsatisfactory. Weak lime-sulphur (1-150) with gelatine (0.1 per cent.) compared favourably with the stronger spray (1-100) with arsenate (0.4 per cent.) but without gelatine, when applied twice, post-blossom. On Belle de Boskoop, soda-soap solution (20-10-100), lime-sulphur (1-100) and a sulphur dust, respectively, gave the best results. All were applied twice, pre-blossom. Soda-soap solution was harmful in 1929, and lime-sulphur in both years proved unsafe, each spray causing fruit drop. Sulphur dust should be used with caution, as it was of doubtful safety in 1929, although no damage resulted in 1930. Colloidal sulphur (0.4 per cent.) with gelatine (0.1 per cent.) was not satisfactory. Previous evidence

in these trials of the influence of root-stock on mildew-susceptibility was confirmed in 1929 and 1930. Cox's Orange Pippin trees on No. 1 stock were pre-eminently susceptible, while those on Nos. XVI, IV, and XV were resistant. T.W.

Celery Diseases; Investigations and Control.

H. H. STIRRUP and J. W. EWAN. *Min. of Agr. and Fish. Bull.*, 1931, 25.

A root rot, caused by *Pythium artotrogus* is described as the chief seedling disease of celery in the Isle of Axholme, north Lincolnshire. Good control may be obtained by soil disinfection with formalin at the rate of 2 to 4 pints per square foot. Both seedlings and adult plants are attacked by *Phoma apiicola*, which infects the region just below the collar. This disease is to some extent seed-borne and is partially controllable by seed treatment with formalin or mercuric chloride. The two distinct types of leaf spot (*Septoria apii*) are described, and it is stated that the standard seed treatments are only partially successful, living spores being obtained from infected seed after immersion in dilute formalin. The best results were given by soaking the seed for periods up to twenty-four hours in 40 per cent. formaldehyde at a dilution of 1 in 400. The results of five years' spraying and dusting experiments showed that home-made Bordeaux mixture gave the best control of leaf spot, the net increase due to spraying in 1926 being estimated at £45 8s. 9d. per 1,500 bundles (*i.e.*, one acre). In 1927 sprayed celery (100 bundles) realised 30s. in the market as compared with 10s. for unsprayed. Commercial quantities of celery seed free from infection by the leaf spot fungus have been obtained by the use of carefully selected seed and regular spraying of the plants during their two years' growth.

T.W.

Commercial Seed Potato Production; Virus Diseases in relation to.

T. WHITEHEAD, J. F. CURRIE, and W. M. DAVIES. *Ann. Appl. Biol.*, 1932, xix, No. 4.

Under a scheme begun in 1927, and supported by a special grant from the Ministry of Agriculture since 1928, an attempt is being made to test the value of certain localities in North Wales for the production of seed potatoes.

Evidence is produced to show that out of fifteen farms originally selected for this purpose, eight have maintained their stocks without increase of virus diseases, three have shown only a slight increase, whilst four have been discarded from the scheme. Replicated yield trials at the College Farm proved that seed mixed from these eleven farms was equal to Scottish " stock " seed, and the value of this Welsh seed was confirmed by trials in a number of Welsh counties in which it was tested against ordinary T.S. Scotch seed.

Concurrently with this, a study has been made of the aphis population of the potato crops at these centres, which has led to the following conclusions :—

(*a*) The absence of increase of virus diseases, and of leaf-roll in particular, at the more successful centres is not due to the scarcity of aphides, nor to the absence of known vectors of the diseases, such as *Myzus persicae*. Neither can it be attributed to the non-infective condition of the aphis vectors present at these centres since representative samples, taken from potato crops, transmitted leaf-roll to healthy plants under glass. With one exception no transmission occurred with any of the species of aphides when taken from apparently healthy plants in

a partially diseased crop. In samples taken from leaf-roll plants transmission only occurred when they included *Myzus persicae*.

(*b*) The accumulated data suggest that the maintenance of health in potato stocks is influenced not merely by the relative abundance of aphides but rather by the relation between the date of maximum infestation and the stage of maturity of the foliage. The more successful centres, each year, showed either a delayed maximum infestation and/or the foliage was cut down earlier than at the less successful centres. The relative movement of aphides within the crops at the different centres is certainly of importance, but this is conditioned by many factors which are still under investigation. T.W.

Narcissus; Fusarium Bulb Rot of.

P. H. Gregory. *Ann. Appl. Biol.*, 1932, xix, No. 4.

In isolations made from stored bulbs *Fusarium bulbigenum* was found most frequently, although two other organisms also occur. Inoculations into healthy bulb tissues with the above *Fusarium* were found to produce the typical symptoms of the storage rot, and the fungus was re-isolated without difficulty. In general, wounding of the tissue was necessary for infection to take place. In a few cases where infection was obtained without artificial wounding, naturally produced wounds are suspected. Inoculations of roots failed to produce the disease. Inoculation with other organisms commonly found on diseased bulbs also failed to give infection, and it is concluded that *F. bulbigenum* is the casual agent of the bulb rot. There is considerable variation in the resistance of different varieties to the fungus.

It is stated that a very frequent point of attack was at the junction of the two components of a double-nosed bulb, although it occasionally occurred in a downward direction from the nose of the bulb; an upward direction from the base is, however, the most usual form of attack. No clear evidence was obtained of the fungus entering the base of the bulb from infected soil through the dying-back of the roots, as is stated to be the case in America. High temperature and high humidity during storage were found to aggravate the disease in an infected stock, but in healthy stocks these same factors did not harm the bulbs or reproduce the disease. The beneficial effects claimed for early planting of stocks as a means of checking the disease has not been substantiated, and the question must still be considered an open one. Support was, however, found for the view put forward by Weiss in America that the disease may be spread during the hot-weather treatment against eelworm. T.W.

Narcissi and Bulb Rot; Warm water treatment of.

E. Van Slogteren. *Weekblad voor Bloembollenkultuur*, 1931, xlii, No. 15.

Experiments at Lisse in Holland, in the control of *Fusarium* bulb rot of narcissi showed that the ordinary hot water treatment by immersion for 1½, 2½, or 3½ hours at 43.5°C. was quite inadequate, and in fact resulted in an average reduction of 37.3 per cent. in the weight of the bulbs of the Colorable variety. On the other hand, immersion for the same periods in 0.5 per cent. uspulun, 0.5 per cent. germisan, or 1 per cent. formalin at 43.5°C. resulted in increased yields of 100.8, 111.6, and 106.9 per cent. respectively. The outcome of eight hours immersion of the bulbs in the same preparation at 18°C. was not so satisfactory. T.W.

Plums; Silver Leaf Disease of.

F. T. Brooks and G. H. Brenchley. *J. Pom. and Hort. Sci.*, 1931, ix, No. 1.

Amongst other aspects of the disease the work deals with the incidence of silver leaf in plum suckers. Silvered suckers, devoid of the mycelium of *Stereum purpureum*, sometimes retain the silvering symptoms until two years after separation from the parent tree. In numerous young worked trees affected by the disease the fungus had entered through one or other of the wounds made in cutting back the stem of the stock in the processes of propagation. As regards the effect of weather on the disease it is stated that hot, dry summers promote recovery, and that if a tree does not die during the first few years of attack its chances of recovery are good. The greatest danger of widespread infection occurs after heavy cropping leading to breakage of branches, especially when followed by a wet autumn. Soft grafting wax and home-made white lead paint have again proved most satisfactory in preventing invasion of wounds by the fungus. T.W.

Potato Blight; Correlation of Weather conditions with outbreaks of.

S. P. Wiltshire. *Quart. J. R. Meteorol. Soc.*, 1931, Vol. lvii.

The writer briefly reviews the work of Dutch investigators on the correlation between weather conditions and outbreaks of potato blight, resulting in the organisation in that country of a spray-warning service; he then discusses the applicability of the data obtained in Holland to English conditions. An examination of twenty-six outbreaks of blight in England and Wales in the light of tabulated data supplied by the Meteorological Office showed that van Everdingen's four conditions for the development of the disease (night temperature below the dew point for at least four hours, minimum temperature of 10°C., mean cloudiness for the next day of 0.8 or above, and rainfall during the next twenty-four hours of at least 0.1 m.m.) were completely fulfilled during the preceding fortnight in eighteen cases. In one other case they were almost entirely fulfilled within the preceding fortnight and completely so within the preceding twenty-three days, whilst in the other seven cases the requirements were almost exactly satisfied during the preceding fortnight. The writer concludes that van Everdingen's conditions are therefore applicable to this country. It remained to ascertain whether these four conditions invariably resulted in outbreaks within the following fortnight. To do this the weather records were analysed from the 15th April to within sixteen days of the outbreak for eight outbreaks following completely favourable days. The results indicate that a number of favourable days occur which are not followed within fifteen days by blight epidemics, although the latter often occur within thirty days. This also was found in a few cases in van Everdingen's data. If the Dutch conditions are exactly adhered to, then only eighteen out of twenty-six British records completely satisfy these conditions as compared with van Everdingen's twenty-nine out of thirty. Allowing a deviation of 10 per cent. in one factor alone, all the British outbreaks except three are preceded by almost favourable days within the fortnight before an outbreak, but at the same time the number of the almost favourable days not followed by blight outbreaks is greatly increased. T.W.

Roses; Black Spot of.

D. E. Green. *J. R. Hort. Soc.*, 1932, lvii, No. 1.

Some 350 varieties are arranged in groups according to their reaction to the fungus (*Diplocarpon rosae*) causing black spot. Juliet bushes sprayed in 1930 with 4-4-50 Bordeaux plus saponin (1 oz. to 50 galls.) were markedly superior in 1931 to those left untreated. T.W.

Seed Disinfecton; Effect of—in Northern Ireland.

A. E. Muskett and H. Cairns. *Ann. Appl. Biol.*, 1932, xix, No. 4.

The paper deals with a series of experiments carried out in Northern Ireland over a period of three years in order to determine the value of various seed treatments for controlling smuts and for use as general seed disinfectants in connection with the cultivation of the oat crop.

In so far as the control of oat smuts is concerned and at the concentrations used in these experiments, copper sulphate and copper carbonate proved to be of some value but caused definite injury to the crop, while sulphur and gypsum proved to have no fungicidal value. Formaldehyde gave complete control in nearly every case, the sprinkle method being considered more satisfactory than steeping, as it is more easily carried out and as the results obtained indicate that in some cases steeping may cause crop injury. The organic mercurial—" Ceresan "—gave almost as good results as formaldehyde.

As general seed disinfectants the organic mercurials—" Ceresan " and " Abavit B "—proved to be more satisfactory than formaldehyde, the average increase in grain yield from these plots being approximately 80 per cent. above the yield from the formaldehyde plots, which in turn showed a yield increase of 16 per cent. above the controls.

It is suggested that the greater efficiency of organic mercurials is due to the fact that the fungicide is retained by the grain at the time of sowing and remains operative during the early stages of crop development without causing injury to the plants. The fact that oat grain has been treated with " Ceresan " and " Abavit B " at varying intervals before sowing with complete success indicates that this method of treatment possesses a distinct advantage over the formaldehyde method where, in order to preclude possible injury during germination, it is necessary to carry out the treatment immediately prior to sowing. No cases of poisoning as a result of the use of organic mercurials have occurred so far and it is possible that by taking reasonable precautions the use of these compounds for seed dressing may be safely advocated.

T.W.

Tomato Leaf-Mould; Control of.

W. F. Bewley and O. B. Orchard. *Ann. Appl. Biol.*, 1932, xix, No. 2.

Tomato leaf-mould may be held in check by attention to atmospheric temperature and humidity. Varieties resistant to this disease are known, but they are not suitable for commercial work. Attempts are being made to breed varieties combining resistance with crop excellence. The disease has been controlled by spraying with salicylanilide paste, sold under the name of " Shirlan Paste ", combined with a sulphonated oil sold as Agral I; the proportions recommended are as follows:—$\frac{1}{8}$ oz. Shirlan Paste, $\frac{1}{4}$ oz. Agral I, 1 gallon water. The powder, Agral I, should be sprinkled into the water and mixed by stirring vigorously. Afterwards the requisite amount of the paste may be added and also mixed by stirring. The spray should be applied at the onset of the

disease, for when this is done a second spray seven days later is sufficient to check its progress for a considerable time. If spraying is left until infection is severe the difficulty of controlling it is intensified greatly. In preliminary experiments the above spray mixture has also provided a satisfactory control of cucumber mildew (*Erysiphe cichoracearum*)—although it has not been possible to experiment with very young plants on a large scale, and more work is necessary. Also powdery mildew of the chrysanthemum (*Oidium Chrysanthemi*) and of the rose (*Sphaerotheca pannosa*) has been controlled after a few applications, and it is possible that the spray may prove useful against other diseases of glasshouse plants. T.W.

Leaflets. MINISTRY OF AGRICULTURE AND FISHERIES.

The following Advisory Leaflets of interest to those concerned in the control of crop diseases have been recently issued.

No. 85. The Downy Mildew of the Onion. December, 1931.
No. 99. Powdery Scab of Potatoes. March, 1932.
No. 107. " Black Leg " of Potatoes. April, 1932.
No. 129. Loganberry Cultivation. August, 1932.
No. 130. Carnations. July, 1932.
No. 139. Mosaic and Allied Diseases of the Potato. September, 1932.
No. 151. The Cultivation of Parsnips. December, 1932.

T.W.

SOILS AND MANURES.

Abstractor:

RICE WILLIAMS, M.Sc., University College, Bangor.

Lime; Some Chemical and Bacteriological effects of various kinds and amounts of—on certain Southern Iowa Soils.

Part I.—Laboratory and Greenhouse Experiments.

R. H. WALKER, P. E. BROWN, and A. W. YOUNG. *Iowa Sta. Research Bull.*, 1932, 148, 57-120.

The following are some of the results obtained. The degree of fineness and the chemical composition of the lime used had a large influence on its reactions with the base exchange complex of soils. Calcium and magnesium carbonates and limestones increased the yield of wheat over that obtained on untreated soils. Magnesium carbonate and dolomitic limestones were slightly more effective than the corresponding calcium compounds. Magnesium carbonate was slightly more effective than calcium carbonate in increasing crop yield and nitrogen content of clover crops. A similar but smaller effect was observed when using a calcium and a dolomitic limestone. R.W.

Lime; The use of—in Agriculture.

Min. Agr. and Fisheries Bull., 1932, No. 35, 0-19.

This bulletin consists of four sections, in which the following are discussed:—(1) the need for lime; (2) comparative values of different forms of lime; (3) application of lime; and (4) lime surveys. R.W.

Limestone Particles of different sizes; Relative effectiveness.

T. L. Lyon. *New York Cornell Sta. Bull.*, 1931, No. 581, 0-18.

The dressings of very finely ground limestone ($<$ 200 mesh) produced larger yields when first applied, but the beneficial effect disappeared more rapidly than coarser (50-80 mesh) dressings. Of the fractions used the coarsest (5-10 mesh) material was the only fraction that failed to show a beneficial effect as time progressed. It is suggested that a soft limestone should be ground to a condition in which all the particles would pass through a 10 mesh sieve. This would give enough of the finer sized particles to make the limestone immediately effective. On the other hand a hard limestone should be pulverised more finely than the soft stone. R.W.

Manures and Manuring.

Min. Agr. and Fisheries Bull., 1931, No. 36, 0-85.

Information for farmers regarding organic manures (farmyard manure, liquid manure, poultry manure, waste organic substances, town refuse and sea weed), artificial fertilisers, compound manures, valuation of manures and some general suggestions for the manuring of farm crops is given in a compact form. R.W.

Moisture and Nitrate Content of field soils receiving different methods of cultivation; Variations in.

R. P. Bartholomew. *Arkansas Sta. Bull.*, 1932, 270.

Little difference was observed in the amounts of nitrates produced in soils on which weeds were destroyed by cultivation: but when weeds were removed by scraping with a hoe, the average content of nitrate in the soil remained slightly higher than by other methods of cultivation, because the loss by leaching was smaller during the growing season. The moisture and nitrate contents were considerably lowered in soils when the weeds were permitted to grow owing to their being used up by the weeds.

Medium-deep and deep methods of cultivation allowed rapid absorption of moisture from limited rainfall, whereas very shallow cultivation, scraping with a hoe, and no cultivation, favoured a rapid run-off of the rain. No difference in the moisture content was observed when the rain was plentiful and well distributed where the soil was kept free from weeds by cultivation. R.W.

Nitrification Processes; Activity of—in the fall and winter months.

R. P. Bartholomew. *J. Amer. Soc. Agron.*, 1932, 24, 435-42.

Work at the Arkansas Experiment Station shows that nitrification occurred during the autumn and winter months but nitrates disappeared in relatively large quantities from soils not planted to cover crops. These crops were found of value as a means of preventing the losses of soluble nitrogen compounds. R.W.

Phosphate in relation to Permanent Pasture Fertilisation; The Movement and Fixation of.

A. R. Midgley. *J. Amer. Soc. Agron.*, 1931, 23, 788-99.

The results of field and laboratory experiments carried out at Wisconsin show that superphosphate when applied as a surface dressing moves down very slowly. Most of the phosphate remains within the surface inch of the soil even after an interval of six months. Maximum

results cannot be obtained immediately unless the phosphate is thoroughly mixed with the soil. Alternate wetting and drying is shown to be one of the most important factors in the fixation of superphosphate in soils. Other fertiliser salts when mixed with superphosphate greatly influence its movement through soils. It is increased by nitrate of soda and slightly decreased by the sulphates of potash and ammonia.

R.W.

Phosphate Penetration in field soils.

R. E. Stephenson and H. D. Chapman. *J. Amer. Soc. Agron.*, 1931, 23, 759-70.

Appreciable penetration of phosphate below the surface 12 inches was found in light to medium textured soils; but little or no penetration appeared to have taken place in very heavy soils. While there was a marked penetration below the surface 12 inches in plots receiving superphosphate, there was no evidence of penetration in similar plots receiving bone meal. There are indications that the phosphates in farmyard manure move readily through the soil. R.W.

Poultry Manure; The production of kiln-dried.

R. Sayce and F. Hanley. *J. Min. Agr.*, 1932, 39, 656-663.

A method for the drying—in a kiln, similar to that used in maltings—and grinding of poultry manure so as to give a material containing from 7-10 per cent. of moisture and ground to pass a one-eighth inch mesh is described. The material has an analysis similar to organic manures of the castor meal or rape cake type. R.W.

Phosphoric Acid in the soil; Conservation of Water-Soluble.

H. Elleder. *Superphosphate*, 1931, 12, 289.

Experiments carried out at the Experimental Station of the Agricultural Council of Bohemia on a heavy red soil showed that after thirty-two days about 34 per cent. of the P_2O_5 was still available in water soluble form and that during the first two weeks after the application of the phosphate about 57 per cent. of the P_2O_5 was at the disposal of the plants in water-soluble form. R.W.

Phosphate deficiency in the soils of Montana.

Univ. of Montana Agr. Expt. Sta. Bull., 1931, 240.

Increased yields of lucerne were obtained by the addition of superphosphate to soils in the districts of Montana where cattle suffered from softening of bones and have the habit of chewing bones. In the majority of cases it was found that the phosphoric acid content of the lucerne hay was considerably increased by fertilisation with superphosphate. R.W.

Rock Phosphate; Availability of—as indicated by Phosphorus assimilation of plants.

J. W. Ames and K. Kitsuta. *J. Amer. Soc. Agron.*, 1932, 24, No. 2, 108-22.

The results of pot experiments carried out at the Ohio Experiment Station are given. When limestone and phosphate were added simultaneously, a decreased assimilation of phosphate by plants, due to the reduction in availability caused by increased basicity was observed. This effect was more pronounced with rock phosphate than with superphosphate, and was not shown to the same extent when rock phosphate

was added to a previously limed field soil. The addition of limestone to an acid soil, however, increased the assimilation from the natural supply. The fineness of grinding appeared to be an important factor in the availability of rock phosphate. R.W.

Superphosphate and Basic Slag; Percolation experiments with—carried out on twelve soils.

C. Krugel, C. Deyspring and F. Heinrich. *Superphosphate*, 1932, 7, 129-35.

These experiments were carried out at the Hamburg Experimental Station. It was found that when the dressings were similar to those applied in practice and the leaching similar to that occuring under natural conditions, no risk of the phosphoric acid of the superphosphate or basic slag being washed out by drainage water was incurred on any cultivated soils. Even with fertiliser applications of from five to six times the normal and a precipitation two or three times as heavy as the normal, the loss by leaching is so small as to be of no practical importance. The authors regard the opinion occasionally advanced that the water-soluble phosphoric acid of superphosphate can be washed out as erroneous, so far as the conditions obtaining in agricultural practice are concerned. R.W.

AGRICULTURAL BOOKS, 1932.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of agriculture published during the year 1932, together with a few omitted from the list for 1931. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, *third edition*, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

ALLEN, L. A. The Mineral constituents and citric acid content of milk. Repr. from *The Journal of Dairy Research*, Vol. III, 1931. Cambridge : University Press, 1931. pp. 52. bibl. ... ...

ANDERSON, A. L. Swine enterprises. Chicago : Lippincott, 1931. pp. 458. ill., diags., bibl. $2.0

ASTOR, W., *Viscount Astor, and* MURRAY, K. A. H. Land and life : the economic national policy for agriculture. London : Gollancz, 1932. pp. 192. diags., bibl. ... ... 5s 0d.

BRUMLEY, O. V. A Text-book of the diseases of the small domestic animals. . . . *2nd ed. rev.* London : Baillière, Tindall & Cox, 1931. pp. xxii, 17-612. 25s. 0d.

CARRIER, E. H. Water and grass : a study in the pastoral economy of Southern Europe. London : Christophers, 1932. pp. xii, 434. fdg. maps, diags. ... 21s. 0d.

CLOUSTON, D. Plant diseases of the garden. Aberdeen : Wyllie, (1932). pp. 52. ... ... 1s. 6d.

COMBER, N. M. An Introduction to the scientific study of the soil. . . . *2nd ed.* London : Arnold, 1932. pp. 208. diags., bibl. ... ... 7s. 6d.

CRAN, M., *formerly* DUDLEY, *Mrs.* G. Gardens in America. London : Herbert Jenkins, 1931. pp. 320. front., ill. ... ... 10s. 6d.

DARLINGTON, C. D. Chromosomes and plant-breeding. London : Macmillan, 1932. pp. xiv, 112. ill., diags. ... ... 7s. 6d.

DAVIES, R. E. Pigs and bacon curing . . . *2nd ed. rev.* London : Crosby Lockwood, 1931. pp. xiv, 110. pls., diags. ... ... 4s. 6d.

DAY, F. H. CRIPPS- The Manor Farm . . . to which are added reprint-facsimiles of The Boke of Husbandry, an English translation of the XIIth century tract on husbandry, by Walter of Henley, ascribed to Robert Grosseteste and printed by Wynkyn de Worde, c. 1510; and The Booke of Thrift, containing English translations of the same tract and of the anonymous XIIIth century tract Hosbonderie, by James Bellot, printed in 1589. London: Quaritch, 1931. pp. xxxviii, 114, [66.] pl. ... ... 36s. 0d.

DICKINSON, S., *and* LEWIS, H. R. Poultry enterprises. Chicago: Lippincott, 1931. pp. vi, [ii], 424. front., ill., diags., bibl. $2.0

DUTCHER, R. A., *and* HALEY, D. E. Introduction to agricultural biochemistry. New York: Wiley, 1932. pp. x, 484. ill. $4.50

FARTHING, F. H. Saturday in my garden. . . . *9th ed. rev.* by A. C. Bartlett. London: Richards, 1932. pp. 484. front., pls., diags. ... ... 7s. 6d.

GAIGER, S. H., *and* DAVIES, G. O. Veterinary pathology and bacteriology. London: Baillière, Tindall & Cox, 1932. pp. viii, 610. ill., diags. ... 25s. 0d.

HALL, *Sir* A. D. The Soil . . . *4th ed. rev.* London: Murray, 1931. pp. xviii, 388. front., ill., pls., bibl. ... ... 9s. 0d.

HALL, C. J. J. VAN. Cacao. *2nd ed.* London: Macmillan, 1932. pp. xviii, 514. ill., diags. ... ... 28s. 0d.

HORACE PLUNKETT FOUNDATION, THE. Agricultural cooperation in Ireland: a survey . . . London: Routledge, 1931. pp. xiv, 424. ... ... 7s. 6d.

KEEBLE, *Sir* F. Fertilizers and food production on arable and grass land. Oxford University Press, 1932. pp. x, [ii], 196. fdg. pl., diags. ... ... 5s. 0d.

KELLY, E., *and* CLEMENT, C. E. Market milk, by E. K. and C. E. Clement. New York: Wiley, 1931. pp. xxii, 490. ill., bibl. $4.50

LONDON: *College of Estate Management.* Reports of the college travelling scholars in agriculture. No. 2. Farm management research technique [by] R. McG. Carslaw. Printed for private circulation, 1931. pp. viii, 232. fdg. charts. ... ...

MACSELF, A. J. The Amateur's greenhouse. London: Collingridge [1931]. pp. xii, 276. front., ill., pls., diags. ... ... 7s. 6d.

MARSHALL, F. H. A., *and* HALNAN, E. T. Physiology of farm animals. Cambridge: University Press, 1932. pp. xiv, 366. ill., diags. ... ... 15s. 0d.

MIDDLETON, A. D. The Grey Squirrel: the introduction and spread of the American grey squirrel in the British Isles, its habits, food, and relations with the native fauna of the country. London: Sidgwick and Jackson, 1931. pp. viii, 108. front., pls., bibl. ... ... 4s. 6d.

NEWMAN, J. The Agricultural life of the Jews in Babylonia between the years 200 C.E. and 500 C.E. London: Oxford University Press, 1932. pp. xii, 216. map, bibl. ... ... 8s. 0d.

OXFORD. *University. Agricultural Economics Research Institute.* The Agricultural depression of 1931, its nature and incidence, by M. Messer. Oxford: Clarendon Press, 1932. pp. 32. ... ... 1s. 0d.

Go East for a farm: a study of rural migration by E. Lorrain Smith. Oxford: Clarendon Press, 1932. pp. 54. ... ... 2s. 0d.

Problems of milk distribution, by F. J. Prewett. Oxford: Clarendon Press, 1932. pp. 32. ... 1s. 0d.

POWERS, W. L., *and* TEETER, T. A. H. Land drainage. . . . *2nd ed. rev. and enl.* New York: Wiley, 1932. pp. x, 354. ill., diags., bibl. *Wiley Agricultural Engineering Series* $3.25

PREWETT, F. J. "Manufacturing milk": a survey of milk marketing and utilization in West Cornwall. Oxford: Clarendon Press, 1932. pp. 34. maps, diags. ... ... 2s. 6d.

READING. *University. National Institute for Research in Dairying.* Bacteriological control of milk: a practical guide for media preparation and milk testing, by A. G. House. Cambridge: University Press, 1931. pp. xii, 60. ill., diags. ... 3s. 6d.

RITCHIE, J. Beasts and birds as farm pests. Edinburgh: Oliver & Boyd, 1931. pp. xii, 270. ill., diags. 12s. 6d.

ROHDE, E. S. Oxford's college gardens. London: Jenkins, 1932. pp. xii, 194. col. front., pls. (some col.) ... ... 42s. 0d.

ROYAL HORTICULTURAL SOCIETY. Conifers in cultivation: the report of the conifer conference held by the Royal Horticultural Society, Nov. 10-12, 1931. Edit. by P. J. Chittenden. London: The Society, 1932. pp. [iv], 634. ill., bibl. ... ... 21s. 0d.

RUSSELL, *Sir* E. J. Soil conditions and plant growth . . . *6th ed.* London: Longmans, 1932. pp. viii, 636. front. (port.), pls., diags., bibl. ... ... 21s. 0d.

SANDERS, T. W. Sanders' Encyclopaedia of gardening. . . . *21st ed.* Rev. by A. J. Macself. London: Collingridge, [1932]. pp. xviii, [ii], 478. front. (port.) ... ... 7s. 6d.

SANDERSON, E. D. Insect pests of farm, garden, and orchard, by E. D. S., *3rd ed. rev.* . . . by L. M. Peairs. New York: Wiley, 1931. pp. viii, 568. ill., diags. $4.50

SANSOME, F. W., *and* PHILP, J. Recent advances in plant genetics. London: Churchill, 1932. pp. x, 414. pls., diags., bibl. ... ... 15s. 0d.

SPENCER, A. J. The Agricultural Holdings Act 1923, with explanatory notes . . . by A. J. S. . . . *8th ed.* London: Stevens, 1931. pp. xxiv, 326. ... 12s. 6d.

STALIN, J. Building collective farms. New York (Pr. in Great Britain): Workers' Library Publishers, 1931. pp. viii, 184. *Stalin Pocket Series* ... 2s. 6d.

STONE, A. A. Farm Tractors. New York: Wiley, 1932. pp. viii, 492. ill., diags. $3.75

THOMPSON, H. C. Vegetable crops . . . *2nd ed.* New York: McGraw Hill Book Co., 1931. pp. x, 560. ill., bibl. $5.0

TROUP, R. S. Exotic forest trees in the British Empire. Oxford: Clarendon Press, 1932. pp. viii, 260. fdg. maps, bibl. ... ... 20s. 0d.

VAN ES, LEUNIS. The Principles of animal hygiene and preventive veterinary medicine. New York: Wiley, 1932. pp. x, 768. ill., diags. $6.50

[WALLOP, G. V.], *Viscount Lymington.* Horn, hoof, and corn: the future of British agriculture. London: Faber and Faber, 1932. pp. 210 ... ... 6s. 0d.

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CONTENTS.

THE DIARY OF A CARDIGANSHIRE FARMER, 1870—1900.

By J. LLEFELYS DAVIES, M.Sc.
University College, Aberystwyth.

Farmers passing through the present period of agricultural depression frequently refer to the good old days of prosperity in Welsh farming. Those good old days vary according to the age and recollection of the farmer. To most modern farmers, the pre-war period typifies all that was desirable to working farmers : cheap and abundant labour; stable prices at a reasonable level with a slight rising tendency; quiet political and economic conditions and average harvest seasons. But there are older people in the farming community who compare the present depression almost automatically with the last decades of the nineteenth century. Farming conditions in the two recognised periods of depression were widely different, and both were difficult periods for farmers. The problems and conditions of the present depression will be recollected for generations by farmers, and a tradition of hardship will gradually evolve.

One must recognise the period 1870 to 1900 as one of the most important formulating periods in the history of farming in this country. Actual records of economic facts of the industry at that time are scarce, but several general features are fundamentally important. The march of industrialism had proceeded far in many parts of the country. Most of the great industrial areas, Lancashire, Yorkshire, the North East, and the Black Country, had become thickly populated, and secondary industries were rapidly developing on the established basis of coal, iron and steel. Most of the important railway lines had been laid down by this time and even Wales was tolerably served by the main rail routes. Agriculture in the country as a whole was rapidly deserting the traditions of corn growing and increasing supplies of cereals were arriving from North America. The increasing industrial population with a gradually rising standard of living meant increased demand for all classes of livestock and their products. Imports of these products from overseas were increasing, and this feature has continued right up to modern times. In many ways, therefore, the foundations of the present farming economy in this country, diverse though it is, were laid in the closing decades of the last century.

Speaking more particularly of Wales the general outline of agriculture is very similar to-day to what it was fifty or sixty years ago. The main farm products for sale still are store cattle and dairy cows; sheep for breeding and feeding; pigs for feeding into finished bacon and pork, with livestock products mainly wool, butter and eggs. In the decades following 1870 these were the prominent products of Welsh farms and the distinctions are those of details and possibly of emphasis rather than of the broad features in comparing the earlier with the later period. It is well known that there was a much greater proportion of the cultivable land under arable conditions than there is to-day. But this was being gradually reduced in many counties, and most of the crops were used for livestock production. The days when wheat and barley were grown for sale almost throughout the Principality were fast disappearing, and farmers had to look more and more to their livestock as the mainstay of the farm income. An important feature of this period was the rapid development of the South Wales industrial area, drawing part of the farm population away from the land, and forming an ever increasing market for the livestock products of Welsh farms. The railways facilitated communication and transport of produce and helped to emphasise the close inter-relation of the industrial and agricultural features of South Wales.

It is interesting to study a farm diary which has now become available because the facts contained therein assist the appreciation of the details in a picture of a farm during that period in relation to a background of conditions which are known in a general way. Deduction from the diary of a single farm naturally suffers from the disadvantage that the facts and conditions described are related to the circumstances of a single case, and may be at variance with general conditions of the industry as a whole. While this may be true, and the facts shown should be taken mainly for illustration, the details of a single case seems more real and colourful than sets of averages however efficiently compiled. The history of farming in Wales even in recent periods has yet to be written adequately, and treatment of individual diaries may help to provide the bricks for that great story.

The diary in this case is that of a farm in Mid-Cardiganshire, situated in that hilly district between Felinfach and Llanarth. It formed part of the Aberkerry Estate, and was tenanted by the same family from 1850 to 1900. The size of the farm was around 150 acres, with an annual rental of about £70 per annum on a lease of 21 years from 1870. Even at that date the farming

system was much the same as it is to-day. A dairy herd formed the basis of the livestock enterprises, part of the milk being used for rearing cattle and pigs and part turned into butter and cheese on the farm. From ten to twelve Welsh Black dairy cows were kept, together with two or three breeding sows and thirty breeding ewes. Unfortunately, the diary is far from complete and it has been impossible to make up comprehensive yearly statements from it. As has been the practice generally on Welsh farms, the diary or book of account has been used mainly to record wage contracts and the payments made under them, and such other items as are not settled from day to day on a cash basis. It has also been the habit to record the dates of mating of cows and pigs in the book of account, but it has been and still is, the exception for farmers to enter regularly the cash purchases and sales on the farm. This particular diary contains more information than most, and it has the advantage that it is neatly entered and is continuous for a series of years. The summaries or extracts below shed some light on a variety of farming topics which assist the formulation of an accurate picture of the period in West Wales.

Records of Sales of Produce.

The diary contains interesting summaries for a number of years of the sales off the farm of two important products, namely wool and butter. These are particularly interesting because these products are still prominent in Welsh farming and butter is still made on this farm, although not in the same form or disposed of through the same marketing channels. It must be appreciated, of course, that conditions of sale of wool were entirely different in 1870 from what they are to-day. Within a radius of five miles of this farm, there were not less than eight or ten small woollen mills, depending largely on local supplies of wool; manufacturing cloth and flannel mainly for sale locally. Again, most households used the family cottage spinning wheel and there was considerable demand for wool from the best farms in the cottages of these rural districts. To-day only a small proportion of the wool even in Cardiganshire is manufactured in the few local mills that still remain, and hardly any is used for household spinning. The markets to-day lie in distant Yorkshire, and possibly in countries overseas. The records of sales of wool from the farm are set out in the table below, and the column showing average price per pound is particularly instructive.

That the records of wool sales are incomplete can easily be seen by the irregularity of the quantities shown for individual

years. In some years the farmer obviously held over supplies, while towards the end of the period there were only relatively small quantities sold locally and entered in the book of account. The inference is that the dealer in wool had appeared by this time and was clearing away bulk supplies, paying cash. The separate entries in the diary show that the unit of weight generally was

Record of Wool Sales, 1874-1886.

	Total weight. lb.	*Number of Customers.*	*Average weight per customer. lb.*	*Average price per pound. Pence.*
1874	298	25	12	15½
5	423	21	20	16¼
6	222	13	17	16
7	575	15	38	14¼
8	393	20	20	12
9	163	11	15	12
1880	61	9	7	12
1	620	42	15	13
2	70	7	10	14½
3	109	9	12	12½
4	116	7	16	11½
5	87	6	14	11¼
1886	47	4	12	9¼

5½ lbs. or mutliples thereof termed ' Topstan ' in the local lore. It is uncertain how far the average prices per pound shown in the diagram represent conditions in the wool market at that time. The fact that the wool was sold locally, and especially to the cottagers, probably meant that prices changed more slowly than in the wholesale markets. According to the records, there was no set period at which wool was sold, but sales continued almost throughout the year. The following extract from the diary in the farmer's own phraseology illustrates the local nature of sales and the variety of the customers.

1880.	*lb.*		£	s.	d.
January 28	5½	Martha Drefain	0	5	6
February 4	2	Mary Cwmcastell	0	2	6
February 24	17½	Deilades Bwlch Castell	0	17	6
March 13	12	Mary Josua Mydroilin	0	12	0
March 18	5½	Margaret Felin Drefain	0	5	6
April 7	13	Jane Shon Cridd	0	13	0
May 22	2	Mary Pantstrimon	0	2	0
September 28	2	Jane Shon Cridd	0	2	0
November 5	3	Martha Williams	0	3	0

Prices of wool over this period of thirteen years made over a shilling a pound on this farm, with a range from sixteen to

ninepence. It should be noted that the decline was gradual but almost continuous from 1874 to 1886.

The records of butter sales refer only to sales in casks or tubs at Llandyssul market and a few local sales to workmen or cottagers. But the quantities shown suggest that most of the butter sold is included in the record. There is also a certain consistency in the quantities which indicates that the records are complete or made on a comparable basis from year to year. Practically all the cows calved in the spring months (this can be verified from the records of dates of mating of cows in the diary) and butter was made then as now, mainly in the summer months. The butter was carefully made, and stored with abundant salting in casks which were stored on the farm, to be sold later at the butter fairs. The final market for the butter was in the South Wales mining valleys, and Llandyssul and Carmarthen were important market centres. An interesting feature of the records of butter sales from this farm is that practically all the butter in casks was sold at Llandyssul, either in February or March. There are isolated instances of sales in September or October, but the

Sales of Cask Butter at Llandyssul, 1870-1887.

Year.	*Total Weight. lb.*	*Weight per Cask. lb.*	*Total Cash received.*			*Price per pound. Pence.*
			£	s.	d.	
1870	803	115	12	13	3	12¾
1 ..	773	110	18	6	3	15
2 ...	1,047	116	11	5	0	9½
3	1,092	120	56	7	0	12½
4	869	121	59	3	10	16½
5	770	110	16	1	8	14½
6 ..	858	123	16	9	10	13
7	770	128	16	1	8	14
8 ...	571	111	39	2	4	16½
9 ...	500	125	20	15	6	10
1880	875	125	51	0	6	14
1	1,071	119	11	12	6	10
2	1,020	128	51	15	6	12¼
3	984	123	47	1	6	11½
4	926	116	16	19	7	12¼
5	995	124	39	11	6	9½
6	989	124	39	6	0	9½
1887	814	116	27	9	1	8
Average	874	120	44	2	9	12

great bulk was sold in the spring months after a period of storage on the farm ranging from six to nine months. To satisfy these conditions the butter must have been well made and the percentage of salting must have been appreciably higher than it is with

farm butter at present. Details of quantities and average prices received are shown in the table below for all the cask butter recorded. Sales of smaller quantities even to workmen tended to carry slightly higher prices and every record of small sales shows the price to have been higher than a shilling a pound throughout the period.

The estimate of butter recorded in small lots as local sales would not amount in any year to more than 10 per cent. of cask butter, and allowing for home consumption at the rate of five pounds weekly the estimate of average production is brought up to about 1,200 lb. annually, or about 100-110 lb. per cow. The average of prices of cask butter from 1870 to 1880 was about 13½ pence per lb. compared with about 10 pence per lb. from 1880 to 1890. There are considerable variations from year to year, depending partly on the state of the market and also on the quality of the butter. Frequent reference is made in the diary to occasional casks of butter which had to be sold below market price owing to poor keeping quality of the produce.

The figures of sales of butter in 1878 and 1879 in the table are shown to be much lower than the average, and although the records are not very clear at this point there is no sign of omission. This was the period of poor harvest years and very wet seasons long remembered by Welsh farmers, and these figures of low production illustrate the effects of such disastrous seasons on the produce of the farm. In 1879, low production was associated with abnormally low prices for butter and most other products.

Some items in Costs on the Farm.

(a) Labour.

Rates of wages and other aspects of labour cost loom large in modern discussion on farming topics. Farmers to-day hire workers within the limits fixed by Orders made under the Agricultural Wages (Regulation) Act, and rates of wages for able-bodied workers tend to be stabilised throughout whole areas around the minimum for quite long periods. The minimum in practice is little affected by the yearly course of prices, and the criticism of wage rates at the moment can be appreciated with the agricultural produce index at around 100 and the wage index nearly 170 compared with conditions in pre-war years. Conditions during the period covered by this diary were entirely different. The rural population was much greater and there was a far greater supply of farm labour available. There were two or more

cottage holdings attached to most fair-sized farms, and families worked at the busy seasons on the parent holdings. This was the heyday of '*laissez faire*.' There were no restrictions on wages paid, except some regard for social decency, competition between farms for good workers, and, perhaps more important, the background of competition from the mining valleys of South Wales. But this was also the period of increasing competition of good products from overseas, and the age of increasing use of machinery for farm tasks. It was fortunate for the rural population of Wales that towards the close of the century coal-mining in South Wales still called for the redundant labour of farms.

The records of wages extracted from the diary are reasonably complete for workers hired and paid cash wages. There were other workers, especially at the busy seasons, who were paid partly in kind, either by a grant of potato land or use of men and horses for haulage or work on the small cottage holdings. The wages quoted refer therefore to regular workers boarding and lodging in the farm house, and day workers boarding at the farm but living at home. The summary on pp. 12, 13 and 14 of the diary entries shows the cash wages paid over the period to regular servants.

In addition to the cash wages agreed upon with the regular servants for the normal hiring year from November 11th, there were various perquisites granted to both men and women. It is strange that in the earlier years up to about 1890, perquisites were only granted infrequently, and for several years only the cash wages are recorded. But in the later years almost every agreement mentions one or more perquisites. The original tenant died about this time, his son taking the farm over, and this may account for the difference. There is no evidence that perquisites were not general in the earlier period, but the practice evidently varied from farm to farm. Perquisites granted usually in this case were the produce of two rows of potatoes, approximately 100 yards long; 5½ or 11 lb. of wool, haulage of a load of coal, and sometimes in the case of head men servants, the keep of two sheep or a pony. Some variation from year to year will be noticed in the schedules of labour employed and wages paid above, sometimes three men being hired and other times only two, but this is not significant, and only illustrates the ups and downs of farm practice.

For comparison with wages paid and total costs of labour on Welsh farms at the present time, the total wages paid to regular

Cost of Labour, 1871-1900.

Year.	*Male Workers.* No.	*Male Workers.* Cash Wage	*Female Workers.* No.	*Female Workers.* Cash Wage	*Total.* No.	*Total.* Cash Wage
		£ s. d.		£ s. d.		£ s. d.
1871-72	1	16 0 0	1	7 2 6		
	1	9 0 0				
Total	2	25 0 0	1	7 2 6	3	32 2 6
1872-73	1	14 5 0	1	10 0 0		
Total	1	14 5 0	1	10 0 0	2	24 5 0
1873-74	1	19 0 0	1	7 15 0		
Total	1	19 0 0	1	7 15 0	2	26 15 0
1874-75	1	20 0 0	1	10 0 0		
	1	12 10 0	1	8 0 0		
Total	2	32 10 0	2	18 0 0	1	50 10 0
1875-76	1	16 10 0	1	8 10 0		
	1	13 0 0				
Total	2	29 10 0	1	8 10 0	3	38 0 0
1877-78	1	20 10 0	1	7 0 0		
	1	13 5 0				
Total	2	33 15 0	1	7 0 0	3	10 15 0
1878-9	1	19 10 0	1	13 0 0		
	1 boy	2 12 6	1	11 0 0		
Total	2	22 2 6	2	24 0 0	1	46 2 6
1879-80	1	15 15 0	1	9 5 0		
	1 boy	2 15 0				
Total	2	18 10 0	1	9 5 0	3	27 15 0
1880-1	1	17 0 0	1	10 0 0		
	1	5 10 0				
Total	2	22 10 0	1	10 0 0	3	32 10 0
1881-2	1	17 10 0	1	10 10 0		
	1 boy	2 10 0				
Total	2	20 0 0	1	10 10 0	3	30 10 0
1882-3	1	18 5 0	1	10 0 0		
	1 boy	2 10 0				
Total	2	20 15 0	1	10 0 0	3	30 15 0
1883-4	1	20 0 0	1	10 5 0		
	1	12 10 0				
Total	2	32 10 0	1	10 5 0	3	42 15 0

Cost of Labour, 1871-1900.—Continued.

Year.	*Male Workers.*		*Female Workers.*		*Total.*	
	No.	*Cash Wage*	*No.*	*Cash Wage*	*No.*	*Cash Wage*
		£ s. d.		£ s. d.		£ s. d.
1884-5	1 1 boy	20 0 0 2 5 0	1	10 5 0		
Total	2	22 5 0	1	10 5 0	3	32 10 0
1888-9	1 1 1 boy	15 10 0 13 0 0 4 15 0	1	12 10 0		
Total	3	33 5 0	1	12 10 0	4	45 15 0
1889-90	1 1 1 boy	16 0 0 11 0 0 4 15 0	1	9 0 0		
Total	3	31 15 0	1	9 0 0	4	40 15 0
1890-1	1 1	18 10 0 16 0 0	1	12 10 0		
Total	2	34 10 0	1	12 10 0	3	47 0 0
1891-2	1 1	18 10 0 15 0 0	1	12 10 0		
Total	2	33 10 0	1	12 10 0	3	46 0 0
1892-3	1 1	18 0 0 14 10 0	1	12 10 0		
Total	2	32 10 0	1	12 10 0	3	45 0 0
1893-4	1 1 1 boy	20 0 0 15 0 0 3 0 0	1	12 10 0		
Total	3	38 0 0	1	12 10 0	4	50 10 0
1894-5	1 1	14 15 0 5 10 0	1	13 0 0		
Total	2	20 5 0	1	13 0 0	3	33 5 0
1895-6	1 1	22 0 0 17 0 0	1 1	12 5 0 11 10 0		
Total	2	39 0 0	2	23 15 0	4	62 15 0
1896-7	1 1	22 0 0 15 0 0	1 1	12 10 0 6 0 0		
Total	2	37 0 0	2	18 10 0	4	55 10 0

Cost of Labour, 1871-1900.—Continued.

Year.	Male Workers.		Female Workers.		Total.	
	No.	Cash Wage	No.	Cash Wage	No.	Cash Wage
		£ s. d.		£ s. d.		£ s. d.
1897-8	1	18 0 0	1	18 5 0		
	1	10 0 0	1	8 0 0		
Total	2	28 0 0	2	21 5 0	4	49 5 0
1898-9	1	19 0 0	1	13 10 0		
	1	9 15 0	1	8 15 0		
Total	2	28 15 0	2	22 5 0	4	51 0 0
1899-1900	1	18 10 0	1	12 0 0		
	1	7 10 0				
Total	2	26 0 0	1	12 0 0	3	38 0 0

The year 1876-7 and the three years 1885-8 are omitted from the series because of incompleteness of the records.

servants with payments for semi-regular day workers for six years of complete records are given below :-

Total Cost of Labour, 1871-8.

Year.	Regular Servants.	Day Labour.		Total.
		Cash.	Daily Wage.	
	£ s. d.	£ s. d.		£ s. d.
1871-2	32 2 6	12 16 6	1/-	44 18 0
1872-3	24 5 0	12 16 8	1/2	37 1 8
1873-4	26 15 0	16 17 10	1/3	43 12 10
1874-5	50 10 0	7 9 3	1/3	57 19 3
1875-6	38 0 0	13 9 10	1/3	51 9 10
1877-8	40 15 0	16 5 0	1/3	56 0 0

There are further intermittent references to cash wages paid to day workers at a later period and one can be quoted to illustrate the trend of wages and the annual payments made.

1894-5—136 days, winter 1s. 3d.
147 days, summer 1s. 6d.
Total, £19 11s. 9d.

The data of wages paid to workers should be studied in relation to the prices of produce sold off farms, and the cost of household foods to the workers. It is true that most farm workers in Wales at the time either lived at the farmhouse, and if they were married, they generally had a cottage holding with a

cow, a few pigs and hens. Still it is almost impossible to imagine how families of farm workers were maintained when cash wages of the farm workers would not have been more than 7s. d. per week. An extract from the detailed account between a regular day worker and the farmer in 1871 illustrates this point, as it shows the amount of cash available for family maintenance.

June, 1871.

			£ s. d.
Work done—22 days at 1s. per day		...	1 2 0
Deductions as follows—		s. d.	
June 1	1 lb. butter	1 0	
8	1 lb. butter	1 0	
15	1 lb. butter	1 0	
18	1 Winchester barley	5 0	
22	1 lb. butter	1 0	
28	1 lb. butter	1 0	
Total		10 0	
Net cash paid		...	0 12 0

The remaining four days of the month may have been spent on other farms, making a total of 16s. cash for the whole month. Mention of Winchester barley in the account brings up the question of the dietary of the people. In this district barley bread was the staple food of the farm workers as well as of most of the farm families. 'Bara Can' or white bread remained a semi luxury at least up to the close of the century.

In many parts of Wales, a considerable amount of draining, enclosing of fields and hedging was done towards the close of last century. It is known that on this particular farm, under the guidance of a vigorous farmer with ample capital, what was previously a wet intractable holding was transformed into one of the best farms in the district. Elaborate drains were cut in almost every field and high hedges built, which have since been more of a curse than a blessing, especially in wet harvest seasons. Records of payments made for draining and hedging at piece rates are found in the diary as follows for the years 1875 and 1876.

Cost of Farm Materials.

The bane of many Welsh farmers to-day is the regular account from the Co-operative Society or the village merchant for supplies of feeding stuffs and other farm supplies. With the decline of arable land in modern times farmers have become increasingly dependent on purchased foodstuffs. Even in the mixed farming areas of Cardiganshire there are few farmers nowadays who resist the temptation of purchased foods, and who grow

Draining.

Number of Perches	*Price per perch. Pence.*	*Cash.*
		£ s. d.
7½	10	0 6 3
30½	8	1 0 4
26½	8	0 17 8
10	9	0 7 6
11½	8	0 7 8
2½	9	0 1 10

Hedging.

21	12	1 1 0
14½	15	0 18 1½
22½	8	0 15 0
39½	10	1 12 11
9	12	0 7 6

sufficient supplies of home-grown arable crops for winter fodder. But in this diary there is not a single reference to purchased foods, and it can be safely assumed that livestock were maintained solely on crops grown on the farm. Records of farm materials purchased refer only to manures, lime, coal, grass seeds, and timber for fencing and repairs. The artificial manure is referred to as 'guano,' but local evidence suggests that it was almost entirely superphosphate in the seventies, and later 'guano du bach' or basic slag. Records of purchased materials in the diary are only available for a part of the period 1870-8, and there are omissions in individual years. The extracts below present most of the information which gives some guidance as to quantities used and costs.

Manures purchased.

Year.	*Quantities.*	*Cash Cost.*	*Price per ton.*
	t. c. q.	£ s. d.	£ s. d.
1872	1 11 0	9 6 0	6 0 0
1873	1 18 0	11 8 0	6 0 0
1874	2 8 2	14 11 0	6 1 0
1875	3 16 2*	22 7 6	5 17 6
1876	1 18 2	11 2 0	5 16 6

* Another farm was taken in 1875 and the quantities recorded cover the two holdings.

It is interesting to compare the meagre quantities of artificials in the seventies and the comparatively high price per ton with

modern conditions on the same farm, where not less than 10 tons of artificials of all kinds are used annually on the arable and grassland. But the small amounts of artificials used in the earlier period were supplemented by generous use of lime in almost every season. Examples of the amounts used and the cost read as follows :—

Lime Purchases.

Year.	*Quantities.*	*Cash Cost.*	*Price per ton.*
	t. c. q.	£ s. d.	£ s. d.
1872	18 9 2	13 3 4	0 11 6
1873	17 10 0	12 14 4	0 11 6
1874	22 19 3	16 3 0	0 14 1

The price per ton is shown to be less than half the average price in modern times, but in making the comparison, it should be realised that transport costs do not enter into the prices quoted above. Practically all the lime used on farms in Cardiganshire was hauled direct from the kilns in Carmarthenshire, a distance of not less than thirty miles. There are old men in the countryside even yet who like to wax eloquent on the romance of the days of lime carting in the closing decades of the last century.

Cost of coal does not enter strictly into the farm business, but in the mind of the farmer it is naturally considered a part of the farm budget. In the seventies the nearest railway station was at Llandyssul, and coal was hauled by farmers for all the residents of the village. The following record of prices and quantities is interesting.

Purchases of Coal.

Year.	*Quantity.*	*Cash Cost.*	*Price per ton.*
	t. c. q.	£ s. d.	£ s. d.
1873	2 10 0	2 18 10	1 3 6
1874	1 3 1	1 1 10	1 0 5
1875	4 8 0	3 11 1	0 17 2
1876	3 16 0	2 14 11	0 14 5
1877	3 19 3	2 13 7	0 14 6
1878	4 10 0	2 16 8	0 12 7

It is hardly credible that all the coal recorded was used on the frugal farm, and the probability is that the record was made to be included in a contra account with neighbouring cottagers.

In modern times, when probably most farmers purchase annual supplies of carefully prepared and mixed grass seeds for

temporary leys, it is strange to record that only fifty years ago the basis of most mixtures were the sweepings of hay lofts with minor purchases of red clover seed added. The material on this subject is scanty, but the purchases of grass seeds for a few years can be set out.

Grass Seed Purchases.

	Quantities.	*Cash Cost.*	*Price per pound.*
1872.	lb.	£ s. d.	*pence.*
Red Clover	120	3 5 0	6½
White Clover	12	0 10 0	10
Paces	125	1 2 6	2
Italian ryegrass	100	0 16 6	2
Total		5 14 0	

	Quantities.	*Cash Cost.*	*Price per lb.*
1873.	*lb.*	£ s. d.	*pence.*
Red Clover	80	2 5 5	7
Trefoil	20	0 6 8	4
Total	100	2 12 1	
1875.			
Red Clover	137	3 11 10	6¼
White Clover ...	18	0 15 0	10
Trefoil	42	0 14 0	4
Total	197	5 0 10	

The White Clover referred to was probably the equivalent of the modern White Dutch Clover, and the mixture of clover was used with the abundant ryegrass in the sweepings from the hay lofts.

The only other references to purchases of materials in the diary are for timber bought at local sales for fencing and repairs. An indication of these amounts can be given as follows :—

Cash Cost.

		£ s. d.
1872	..	4 14 0
1873	....	2 9 0
1874	....	3 5 6
1875	....	8 18 9

The data in the diary are not sufficiently complete to enable a summary of total costs of farm materials to be made for individual years to illustrate the comparison between then and now, but sufficient evidence has been given of individual items to appreciate the general conditions of the time.

There is other information of a private character contained in the diary, such as an account of loans made and payments of interest and rent. But one entry is of particular interest at this distance of time. Apparently one of the farmer's daughters married in 1872, and although the bridegroom was of respectable family, and a farmer's son, he was not kindly received by the bride's parents.

Disapproval was registered in the small dowry, the details of which are entered faithfully in the diary. The entries read as follows, after some correction and translation.

November 11th, 1872.—Gave money and things to Sarah.

		£	s.	d.
November 11th	Cash to buy things at Aberayron	3	0	0
November 18th	Cash to buy things at Aberayron	2	0	0
November 30th	Morgan, Carpenter, 2 chairs 11/- and small table 6/-	0	17	0
November 30th	Morgan, Carpenter, other small things	0	11	0
November 30th	Linenpress from the farm value	6	0	0
November 30th	4 cheese—185 lbs.			
November 30th	2 Winchesters wheat	0	17	0
November 30th	2 lb. sugar and ¼ lb. tea	0	1	8½
November 30th	7 lb. soap	0	2	4
November 30th	4 loaves bread	0	4	0
	Cash for small purchases	0	3	7
1873.				
January 3rd	Carpenter—small things	0	1	11
February 18th	Feather bed 58 lb. @ 1/- ...	2	18	0
	Mattress do ..	0	12	0
	Total . . .	£17	8	6½

The cheese was not valued, but estimating it at 4d. per lb. would bring the total to slightly over £20 in all.

There may have been gifts of cattle or sheep, which are not recorded, but that is unlikely, because the tradition is that this old farmer dealt harshly with all his daughters, and bequeathed all his property to his sons.

It remains finally to emphasise that the facts from this diary only indicate a few aspects of the conditions during this period, and it is to be hoped that many such documents will become available and that they will be used in the process of building a true history of rural districts in Wales. Sufficient has been said here to indicate how vastly different were the business aspects of the farm

fifty years ago from what they are to-day. Prices of produce in the seventies were certainly better than they are in our modern thirties, and costs of labour and materials were more favourable to the farmer. Even up to 1885 there is no evidence of depressed conditions, except in the scale of wages and the living conditions of the countryside. From 1885 to 1900, however, was a lean time for Welsh farmers; wages had risen slightly and prices of livestock were particularly low, and it is this latter period that is generally referred to in allusions made by rural folk to-day to the depression in farming towards the close of the nineteenth century.

AGRICULTURAL CO-OPERATIVE SOCIETIES IN WALES: A REVIEW OF THREE YEARS' TRADING IN FARM REQUIREMENTS, 1930-31-32.

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The period 1930 to 1932 was one of falling prices for agricultural commodities in general. It was a difficult period for agriculturists and therefore difficult also for the agricultural co-operative societies selling agricultural requirements. The limited purchasing power of the farmers together with the general difficulties of operating upon a falling market have certainly tested the strength of these organisations and their utility to the agricultural community. That so many of the societies have been able to maintain and in certain cases to increase their business is proof of their sound management and the confidence of farmers in their utility.

The process of elimination of the weaker societies is clearly demonstrated in Table I.

During the seven years 1926 to 1932 sixteen societies ceased operations. During the three years under review three societies ceased to function, whilst one society ceased to trade as a requisite society but its organisation was retained as a Live Stock Improvement Society. These societies were actually in liquidation at the commencement of the trading year 1930 and only the remaining 59 were in a position to carry on trade during the whole

of that year. There were no further liquidations in 1931 or 1932 in spite of the difficult trading conditions.

Whilst the total membership of the societies has been added as a further indication of progress, such a measure is by no means a satisfactory one. Many societies trade with non-members whilst others have a large number of members who do not actually trade with the society. It is satisfactory, however, that in spite of the

TABLE I.

Number of Societies Trading and Membership.

Year.	*No. of Societies.*	*Total No. of Members.*
1926	75	23,610
1927	70	22,967
1928	64	22,362
1929	63	23,783
1930	63	22,779
1931	59	22,574
1932	59	23,015

decline in the number of societies there has not been any large decrease in membership of the movement as a whole. The maintenance of membership with the decline in the number of societies can be partly explained by successful societies taking some of the responsibilities of the liquidated organisations. But in the case of one society which was liquidated in 1930 no society has yet undertaken trading in the area and the loss of membership and trade has been a total loss to the movement. Allowing for this loss, the average membership of the 59 societies still functioning has increased during the three years under review.

There is a marked variation in the total turnover of individual societies; the society with the lowest turnover showed total sales of only £48 in 1932. The society with the highest turnover showed total sales of over £200,000. Table 2 shows the distribution of the societies according to turnover and the number of societies in each group recording net losses and net profits.

During the three years all the 18 societies with sales of £20,000 per annum and over consistently showed net profits. Obviously it is amongst the smaller societies that the weakness of the movement, as measured by low net profits or losses, is to be found. The disappointing feature of the Table is the increase in the number of societies with an annual turnover of between £10,000 and £20,000 which showed net losses in 1932. Two of these societies earned a gross profit of over 9 per cent. during the

year and their main problem appears to be one of careful control of trade costs. The remaining society showed net profits during the years 1930 and 1931 when gross profits amounted to more than 6 per cent. of total sales but during 1932 the gross profit earned fell to less than 4.6 per cent. Although there was a reduction in total trade costs this was not sufficient to meet the reduced gross profit. All the net losses shown by these three societies were, however, less than one half of one per cent. of total sales and there is no reason to anticipate their failure. None of these societies showed consistent losses throughout the three years, only one showing a loss in 1930 and 1932.

TABLE II.

Grouping of Societies according to Total Sales.

Total Sales.	1930.			1931.			1932.		
	No. of Societies.	*Societies showing*		*No. of Societies.*	*Societies showing*		*No. of Societies.*	*Societies showing*	
		Net Prof.	*Net Loss*		*Net Prof.*	*Net Loss*		*Net Prof.*	*Net Loss*
Under £5,000	12	8	4	15	9	6	15	9	6
£5—£10,000	15	13	2	13	11	2	13	11	2
£10—£20,000	13	12	1	13	13	0	13	10	3
£20—£50,000	13	13	0	15	15	0	14	14	0
Over £50,000	5	5	0	3	3	0	4	4	0
Totals	58	51	7	59	51	8	59	48	11

Of the remaining societies showing net losses only two showed net losses in each of the three years. One Society with annual sales of less than £2,000 has shown consistent heavy net losses and decreasing sales. The other society has also failed to maintain its total annual sales and although its net loss in 1930 was only 0.3 per cent. of sales this had increased to 11.9 per cent. by 1932. Whilst the aim of an agricultural co-operative society should not be to show a large net profit at the close of the financial year, societies which show continued net losses over a period of years can scarcely avoid financial difficulties. It is obvious from the Table above that the smaller societies do find difficulty in earning sufficient gross profit to cover the total costs incurred. The difficulty in such cases is to find suitable methods of reducing the trade costs, for many of these societies have little hope of increasing their turnover in their present financial

positions. As far as the movement as a whole is concerned it would be most unfortunate if these societies were liquidated and trade lost because farmers would lose their invested capital as well

TABLE III.

Total Turnover of All Agricultural Co-operative Requisite Societies in Wales.

Year.	*No. of Societies.*	*Cash Turnover.*		*Board of Trade Index No. 1924 = 100.*	*Corrected Figures.**		*Total Cash Sales.*	**Estimated Total Corrected Sales.*
		Requisites.	*Produce.*		*Requisites.*	*Produce.*		
		£						
1926	75	1,116,176	69,588	89.1	1,286,415	78,101	1,215,784	1,364,516
1927	70	1,124,649	47,211	85.2	1,437,380	55,412	1,271,859	1,492,792
1928	64	1,306,162	43,767	84.4	1,547,585	52,091	1,350,129	1,599,679
1929	63	1,259,700	37,180	82.1	1,534,348	45,286	1,296,880	1,579,634
1930	68	1,166,634	36,649	71.9	1,622,578	50,972	1,203,283	1,673,550
1931	59	1,084,757	55,260	62.6	1,732,838	88,275	1,140,017	1,821,113
1932	59	1,132,453	61,947	61.1	1,853,441	101,386	1,194,400	1,954,827

* These figures represent an estimate of the *relative volume* of sales in the different years, or an estimate of the cash sales had the general level of prices remained steady in each of the years.

as their interest in the agricultural co-operative movement. Where possble it appears that the logical procedure in dealing with these small societies is to arrange for some form of amalgamation whereby greater economies in trade costs can be introduced. In certain areas this is quite possible and should be undertaken without delay. In other areas there is little or no possibility of amalgamation, not because of opposition to the principle but because the society is in an area remote from other societies. In such cases if the small society fails a large area is left without any agricultural co-operative organisation, with the further difficulty that after one bitter experience farmers will be reluctant to offer any support to any new society which may be proposed.

Reviewing the total sales of all the societies Table III shows that during the three years cash sales have been well maintained. The figures for the years 1926-32 have been given for comparative purposes. By using the Board of Trade Index Number for wholesale prices the cash sales have been quoted as corrected sales to allow for the general decrease in prices. The column " Total Corrected Sales " shows that the estimated tonnage turnover of goods has increased every year with the exception of 1929. Many of these requisite societies have undertaken the sale of produce on behalf of their purchasing members. Since 1926 there was a marked decrease in the cash sales of produce on behalf of members but recovery set in in 1931 and there was a great increase in 1932. But when allowance is made for the general fall in prices the corrected figure for produce sales shows a marked increase in total turnover of goods.

It is only possible to give a detailed analysis of the " requisites " sales of 50 societies in the group. Taking these 50 societies as representative of the group, Table IV shows the marked predominance of feeding stuffs in their general trade.

The total sales of agricultural implements is certainly low and there appears to be much room for development of this particular type of trade. The general difficulty appears to be the reluctance of manufacturers to offer agencies to agricultural co-operative societies. It is true that a sales agency often carries the responsibility of maintaining a service agency for minor repairs of implements but there are many large societies in the group which could easily maintain such a service. This would be difficult for the smaller societies and it appears that the future possibilities of agricultural co-operative societies in Wales

securing agencies for the large agricultural implement manufacturers rests with the movement in general building up a series of large and financially strong societies scattered throughout the country rather than a large number of smaller independent

TABLE IV.

Classification of Cash Sales of fifty Societies.

Type of Goods.	*Total Cash Sales.*			*% of Total Sales.*		
	1930.	*1931.*	*1932.*	*1930.*	*1931.*	*1932.*
	£	£	£	%	%	%
Feeding Stuffs	590,776	558,591	629,910	72.6	71.4	72.6
Implements	10,511	11,900	10,996	1.3	1.5	1.3
Seeds	28,901	28,165	27,766	3.6	3.6	3.2
Fertilisers ...	60,411	55,490	52,497	7.4	7.1	6.0
Other Sales	122,612	128,211	146,803	15.1	16.4	16.9
Total	813,274	782,357	867,972	100.0	100.0	100.0

societies. " Other Sales " referred to in the Table include a variety of requisites such as groceries, drapery, coal and household requisites. Fertilisers, though the turnover is considerably less than that of feeding stuffs, are an important part of the business of agricultural "requisite " societies. Total cash sales of fertilisers have fallen consistently throughout the three years.

In Table V the Ministry of Agriculture Index Numbers for Feeding Stuffs and for Fertilisers have been used to estimate the tonnage turnover of these two commodities.

TABLE V.

Sales of Feeding Stuffs and Fertilisers by fifty Societies.

	Feeding Stuffs.			*Fertilisers.*		
	Actual Sales.	*Ministry of Agric. Index 1911-13 = 100.*	*Corrected Sales.*	*Actual Sales.*	*Ministry of Agric. Index 1911-13 = 100.*	*Corrected Sales.*
	£			£		
1929		139			100	
1930	590,776	96	615,390	60,111	101	59,845
1931	558,591	83	673,000	55,490	96	57,802
1932	629,910	95	663,068	52,497	90	58,330

While the actual tonnage figures are unknown, the approximate comparative figures are :—

	Feeding Stuffs.	Fertilizers.
1930	100	100
1931 ...	109	96
1932 ...	108	97

Although the cash sales of feeding stuffs fell in 1931, when allowance is made for the fall in prices the estimated total tonnage turnover increased sharply in 1931 and then slightly decreased in 1932. In the case of fertilisers whilst the cash sales fell consistently the tonnage turnover fell in 1931 and increased in 1932 though the increase was not as large as the decrease during the previous year. The results shown in this Table support the general opinion of agriculturists that farmers have tended to increase the use of concentrated feeding stuffs but have decreased the use of artificial manures.

Produce sales have steadily increased since 1930. In Table VI the comparative figures for the three years are given.

TABLE VI.

Classification of Produce Sales by Societies 1930-32.

	Total Cash Sales.			% of Total Sales.		
	1930. £	1931 £	1932 £	1930. %	1931 %	1932 %
Dairy Produce	16,259	36,015	43,636	44.3	65.3	70.5
Eggs and Poultry	18,751	17,813	18,483	51.2	32.2	21.7
Grain	726	303	1,616	2.0	0.5	2.6
Wool	913	1,129	1,357	2.5	2.0	2.2
Livestock	—		1,165	—	—	1.9
Fruit and Market Garden Produce	—	—	690	—	—	1.1
Total	36,649	55,260	61,947	100.0	100.0	100.0

Whilst this Table is of interest it would be misleading to accept the figures given as entirely adequate. Many societies are obliged to undertake a small trade in the sale of farm produce to maintain trade upon a contra account basis. Owing to the nature of the transactions, a large number being small weekly items, adequate records are not kept and full information is not, therefore, available. But the interesting features of the Table are the innovations in 1932 of trading in livestock and market garden produce. The total transactions are small yet they prove that certain societies are aware of the needs of their members and

are prepared to assist in new ventures in order to render service. Whether it is generally advisable that requisite societies should undertake the marketing of farm produce is doubtful but where there is a demand for an organisation to assist in marketing of farm produce and the requisite society is prepared to do the work the experiment is, at least, worthy of careful consideration. The livestock sales were undertaken by a society which had not previously undertaken the marketing of farm produce in response to a demand from its members. The society handling market garden produce had previously undertaken the sale of eggs. The marked decrease in the sale of eggs cannot be wholly accounted for by the decrease in prices. After allowing for the fall in prices the total turnover[1] in 1932 was less than in 1930.

Although the number of societies trading has decreased steadily in recent years, the total number of persons employed by all requisite societies has, during the three years under review, increased from 355 in 1930 to 374 in 1932. The average cash turnover per employee reflected the same downward movement as total cash turnover; but when, again, these figures are corrected for the fall in the general price level it is seen that, in volume, sales per employee have continuously increased.

TABLE VII.

Turnover per Employee, 1930-32.

	No. of Societies.	*Total No. of Employees*	*Total Cash Turnover.*	*Cash Turnover per employee.*	*Board of Trade Wholesale Price Index*	*Comparative Volume of Turnover per employee.*
			£	£	*1924 = 100*	
1930 ...	63	355	1,203,283	3,390	71.9	100
1931	59	366	1,140,017	3,115	62.6	106
1932	59	374	1,194,400	3,191	61.1	111

Throughout the movement it is clear that each employee is being employed more efficiently in that each handled a larger tonnage in 1982 than in 1930. This is probably due to the liquidation of the smaller societies where labour was not used so efficiently.

There is, however, within the group, a very wide distribution of sales per employee. Certain societies in the group failed to

[1] It should be borne in mind that the egg sales refer to sales by societies which are mainly requisite societies and do not refer to the total sales of eggs in Wales through co-operative organisations.

give definite information as to permanent employees but for the remainder of the group the following Table shows the distribution of sales per employee and also shows the number of societies within the groups showing net profits and net losses.

TABLE VIII.

Distribution of Sales per Employee.

Sales per Employee.	1930.			1931.			1932.		
	No. of Societies in each Group.	*Societies showing*		*No. of Societies in each Group.*	*Societies showing*		*No. of Societies in each Group.*	*Societies showing*	
		Net Profit	*Net Loss*		*Net Profit*	*Net Loss*		*Net Profit*	*Net Loss*
Under 1,000	1	—	1	1	1	—	1	1	—
1,000—1,999	6	4	2	13	10	3	12	6	6
2,000—2,999	22	17	5	15	13	2	16	14	2
3,000—3,999	13	13	—	10	9	1	11	10	1
4,000—4,999	6	6	—	6	6	—	6	6	—
5,000—5,999	4	4	—	8	7	1	7	7	—
6,000—6,999	3	3	—	1	1	—	0	—	—
7,000—7,999	0	—	—	0	—	—	0	—	—
8,000—8,999	1	1	—	1	1	—	1	1	—
9,000—9,999	1	—	1	0	—	—	1	1	—
10,000 and over	1	1	—	0	—	—	0	—	—
Totals ...	58	49	9	55	48	7	55	46	9

In 1930 out of the 58 societies 35 had sales per employee between £2,000 and £8,999. Throughout the three years the modal group was 2,000—2,999 though in the years 1931 and 1932 there was not such marked concentration of societies at the mode. Of the societies showing a net loss at the close of the financial years the mode for 1930 was the £2,000—£2,999 group, but for

the two later years it fell to the £1,000—£1,999 group. It is apparent that the lower the sales per employee the higher the percentage of societies showing a net loss. The one society showing

TABLE IX.

Societies grouped by Gross Profits as Percentage of Sales, together with Net Profits and Net Losses.

Gross Profits as per cent. of Sales.	*1930.* No. of Societies in each group.	*1930.* Societies showing Net Profit	*1930.* Societies showing Net Loss	*1931.* No. of Societies in each group.	*1931.* Societies showing Net Profit	*1931.* Societies showing Net Loss	*1932.* No. of Societies in each group.	*1932.* Societies showing Net Profit	*1932.* Societies showing Net Loss
1 — 2.9	1	1	—	2	1	1	3	2	1
3 — 4.9	5	2	3	3	2	1	5	4	1
5 — 6.9	12	11	1	10	9	1	9	8	1
7 — 8.9	16	14	2	11	9	2	11	10	1
9 —10.9	14	14	—	16	16	—	15	12	3
11 —12.9	6	5	1	9	8	1	9	8	1
13 —14.9	4	4	—	2	2	—	2	1	1
15 —16.9	1	1	—	3	3	—	2	2	—
17 +	1	1	—	1	1	—	1	1	—
Totals	60	53	7	57	51	6	57	48	9

in 1930 sales per employee of 9,000 to 9,999 and making a net loss was then in financial difficulties and has now ceased to trade.

In reviewing the gross profit earned by the societies it should be borne in mind that the nature of the trade differs widely throughout the group. Many farmers measure the success of a society by the margin over cost price at which it sells. The

margin or " mark up " is not necessarily the same as gross profit, the latter always being the lower as the " mark up " must carry a margin to cover losses in storage, weighing, etc. The percentage gross profit earned by societies varies widely, two societies actually showing a gross loss[2] during the period under review. The society showing gross profits of 17 per cent. showed also net profits of at least 10 per cent. during the three years. The general practice is to earn high net profits and to distribute a dividend upon purchases at the close of the trading year. But high gross profits are not necessarily associated with high net profits. In 1932 three societies with gross profits varying between 9 per cent. and 11 per cent. made net losses and even one society with a gross profit of 14 per cent. showed a final net loss. The larger proportion of the societies operated at gross profits varying between 5 per cent. and 10.9 per cent. of sales. During 1930 the modal group was 7 per cent. to 8.9 per cent. but during 1931 and 1932 the mode shifted to the range of 9 per cent. to 10.9 per cent. Information as to the distribution of societies according to gross profits earned, as percentage of sales, together with the number of societies showing net profits and losses, is tabulated above.

The distribution of societies according to net profits earned is shown in the Table below.

TABLE X.

Distribution of Societies according to Net Profits earned in the years 1930-31-32.

Net Profits as per cent. of Sales.	*Number of Societies.*		
	1930.	*1931.*	*1932.*
Zero and below (losses)	6	8	11
0—0.99	12	4	7
1—1.99	14	18	11
2—2.99	11	10	11
3—3.99	4	10	9
4—4.99	8	7	4
5—5.99	2	4	4
6—6.99	1	1	1
Over 7	3	2	1
Totals	61	59	59

The final statement of net profits earned by one society in 1930 is not available. In spite of the liquidation of three societies in 1930, two of which failed to show profits, the number

[2] *i.e.*, showing opening stock plus purchases of greater amount than sales plus closing stock.

of societies not showing a net profit in the year 1931 increased. Of the 55 societies showing a net profit in the year 1930, 37 or 67 per cent. were in the groups below 3 per cent. and 41 or 74 per cent. in the groups below 4 per cent. Of the 51 societies showing net profits in 1931 only 27 or 53 per cent. were in the group below 3 per cent. and 37 or 72.5 per cent. were in the groups below 4 per cent. In the last year 48 societes show a profit and of these 29 or 60 per cent. show net profits of less than 3 per cent. and 36 or 75 per cent. were in the groups showing less than 4 per cent. The number of societies showing a net loss increased from below 10 per cent. of the total number in 1930 to nearly 14 per cent. in 1931 and to nearly 19 per cent. in 1932.

With the variations in conditions of operation and the profit or loss results in view it seemed desirable that an effort should be made to discover, if possible, some of the chief causes of differences in results. Hence a study has been made of the relations between—

(1) *a*. Gross Profit as per cent. of Sales, *b*. Net Profit as per cent. of Sales.

(2) *a*. Total Gross Profit as per cent. of Sales, *b*. Total Trade Costs as per cent. of Sales.

(3) *a*. Total Trade Costs as per cent. of Sales, *b*. Salaries and Wages as per cent. of Sales.

(4) *a*. Total Trade Costs as per cent. of Sales, *b*. Net Profits as per cent. of Sales.

(5) *a*. Stock carried as per cent. of Sales, *b*. Net Profits as per cent. of Sales.

The results of the analysis of the relations between these items are of interest although they are somewhat inconclusive.

Gross and Net Profits.

Table IX indicates that the amount of gross profits may have a considerable influence on the determination of the final result in profits or losses. The relationship, however, is closer in 1930 than in the other years. In 1931 the amounts of net profits did not vary exactly with the gross profits, although most of the societies showing losses were in the group with the lower gross profits. In 1932 there was a wider distribution of the societies showing net losses. The degree of association between gross and net profits is shown by the coefficients of correlation :

1930 .... $r = +\ 0.616$
1931 .... $r = +\ 0.482$
1932 .... $r = +\ 0.48$

TABLE XI.

Distribution of Societies according to Total Trade Costs stated as a percentage of Sales.

Percentage of Trade Costs to Sales.	1930.			1931.			1932.		
	No. of Societies.	*Societies showing*		*No. of Societies.*	*Societies showing*		*No. of Societies.*	*Societies showing*	
		Net Profit.	*Net Loss.*		*Net Profit.*	*Net Loss.*		*Net Profit.*	*Net Loss.*
Below 2 %	—	—	—	—	—	—	—	—	—
2— 3.9 %	7	5	2	6	4	2	8	7	1
4— 5.9 %	18	17	1	18	18	—	17	16	1
6— 7.9 %	14	11	3	12	11	1	10	8	2
8— 9.9 %	15	14	1	10	9	1	9	8	1
10—11.9 % ...	3	3	—	7	6	1	8	6	2
12—13.9 %	1	1	—	4	2	2	3	3	—
14—15.9 %	1	1	—	1	1	—	2	—	2
Over 16 %	2	—	2	1	—	1	2	—	2
Totals	61	52	9	59	51	8	59	48	11

While there was fairly high correlation between these items in 1930 some other factors intervened in the later years.

Gross Profits and Trade Costs.

In reviewing the total trade costs of the societies in the group it will be seen by the above Table that there is a wide variation between individual societies when total trade costs are stated as a percentage of sales.

In each year the modal group was that with total trade costs between 4 per cent. and 5.9 per cent. of total sales. In 1930 88 per cent. of the societies had total trade costs of less than 9.9 per cent. of total sales. In 1931 the percentage fell to 78 and in 1932 it fell to nearly 74 per cent. It is obvious from the Table that there is a number of societies with increased trade costs relative to total sales.

The statistical analysis shows a consistently high correlation in each of the years :—

1930	.	r = + 0.702
1931		r = + 0.719
1932		r = + 0.745

The estimate of trade costs is one of the chief determinants of the margin of gross profits which will be taken, although according to the conditions of selling the actual margin may be made narrower or wider than is needed to cover costs. From the analysis of the records of 1932 it may be stated that when Trade Costs are taken at 7 per cent. of sales the gross profits will vary between 6.5 and 10.9 per cent. Conversely, when Gross Profits are taken as 10 per cent. of sales Trade Costs will vary between about 6 and 10.2 per cent.

Trade Costs, and Salaries and Wages.

The larger proportion of trade costs consists of salaries and wages paid, and it will be expected that a close correlation will be found between these items. Table 12 sets out the grouping of societies on the range of salaries and wages.

The modal group in each year was that varying between 8 per cent. and 8.9 per cent. but it will be seen that the amount of salaries and wages paid relative to turnover has tended to increase. In 1930 about 21 per cent. had a salaries and wages bill over 4.9 per cent. but this increased in 1931 to nearly 26 per cent. and in 1932 to 31 per cent.

The coefficients of correlation are found to vary a little from year to year, but on the whole are high :

1930	....	r = + 0.869
1931	....	r = + 0.864
1932	....	r = + 0.9006

Taking Salaries and Wages at 4 per cent. on the 1932 records

TABLE XII.

Grouping of Societies according to Salaries and Wages stated as a per cent of Sales.

Percentage of Salaries and Wages to Sales.	1930.			1931.			1932.		
	No. of Societies.	Societies showing		No. of Societies.	Societies showing		No. of Societies.	Societies showing	
		Net Profit.	Net Loss.		Net Profit.	Net Loss.		Net Profit.	Net Loss.
Under 1 %	—	—	—	—	—	—	—	—	—
1—1.9 %	2	2	—	3	3	—	4	4	—
2—2.9 %	13	10	3	8	6	2	11	11	—
3—3.9 %	18	18	—	20	20	—	15	12	3
4—4.9 %	14	10	4	13	12	1	10	9	1
5—5.9 %	6	6	—	3	3	—	7	6	1
6—6.9 %	4	4	—	6	3	3	7	5	2
7—7.9% ...	1	1	—	2	2	—	1	1	—
Over 8 %	2	—	2	3	2	1	3	—	3
Totals	60	51	9	58	51	7	58	48	10

total trade costs will vary between 5.5 and 8.7 per cent. of sales,

Or, conversely, if total Trade Costs are taken at 8 per cent.

TABLE XIII.

Stock as per cent. of Turnover, together with Net Profits and Losses.

Stock as per cent. of Turnover.	*1930.*			*1931.*			*1932.*		
	No. of Societies.	*Societies showing*		*No. of Societies.*	*Societies showing*		*No. of Societies.*	*Societies showing*	
		Net. Profit.	*Net. Loss.*		*Net. Profit.*	*Net. Loss.*		*Net. Profit.*	*Net. Loss.*
0— 0.9	—	—	—	1	1	—	—	—	—
1— 1.9	1	1	—	5	5	—	1	1	—
2— 2.9	4	4	—	5	5	—	3	3	—
3— 3.9	3	3	—	7	7	—	7	6	1
4— 4.9	9	8	1	8	8	—	4	1	—
5— 5.9	7	6	1	5	4	1	10	9	1
6— 6.9	4	4	—	1	1	—	4	3	1
7— 7.9	4	4	—	4	3	1	6	6	—
8— 8.9	6	5	1	6	5	1	4	2	2
9— 9.9	2	1	1	5	4	1	4	4	—
10—10.9	5	4	1	2	2	—	2	1	1
11—11.9	4	4	—	1	1	—	4	4	—
12—12.9	3	3	—	—	—	—	1	—	1
13—13.9	1	1	—	2	2	—	1	1	—
14 and over	6	4	2	5	2	3	6	3	3
Totals	59	52	7	57	50	7	57	47	10

Salaries and Wages will range between 3.7 and 5.2 per cent. of sales.

Total Trade Costs and Net Profits.

Strange as it may appear, there is no close connection between total trade costs stated as a percentage of sales and final results in net profits or losses. The conditions of trading and methods of organisation are so varied that many influences combine to determine final results. Trade costs must be amongst these influences, but the influence of this item is not sufficiently strong or direct to lend itself to direct demonstration.

Stocks carried and Profits.

It might be expected that relatively high or low rates of turnover would have an appreciable influence on the final results in profits or losses. One measure of rate of turnover is the proportion of stock carried to total annual sales, but the only practical measure of stocks over a large number of societies is the mean of the stock-in-hand at the opening and closing of the financial year. Table 18 shows the distribution of societies according to proportion of stock carried stated as a percentage of annual turnover.

The absence of any losses amongst societies with less than 4 per cent. of stocks, except in 1932, may be noted; and the occurrence of high proportion of losses with stocks of over 14 per cent. is remarkable. When societies begin to carry over 12 per cent. of stocks there is a very high risk of financial loss. But within the range of 4 and 12 per cent. of stocks many other influences in the general conditions of trading may over-power such direct influence as the proportion of stocks may exercise on the final result. In 1930 approximately 68 per cent. of the group had stocks less than 10 per cent. of turnover, whilst the corresponding figures for 1931 and 1932 respectively were 84 and 76 per cent. There is a marked difference between the proportion of stocks to turnover in the societies showing net profits and those showing net losses.

The statistical analysis shows that although a fairly close association between high stocks and low net profits may be expected, on the ground of the influence of cost of carrying stock and of depreciation of stocks, this expectation will not always be realised. There is a slight negative correlation between proportion of stocks to turnover and net profits earned, but it is too low to be reliable.

Average Percentage of Stocks to Turnover.

	Societies Showing Net Profits.	*Societies Showing Net Losses.*
1930	7.6	9.8
1931	6.0	10.9
1932	7.1	10.1

A test of the association between proportion of stocks and gross profits has also been made, and while a slight positive correlation is found it is again too low to have any significance.

It is difficult to secure an adequate and satisfactory measure of trading efficiency which may be applied to the trading results of agricultural requisite societies in Wales. Perhaps the most satisfactory is found in the maintenance of goods turnover. But even this fails as a true measure, for what is really required is not merely maintenance of turnover but maintenance or increase of the proportion of turnover which they have held in the past. If there is a general tendency to increase total purchases of farm requisites in Wales and the movement only maintains its turnover it is relatively losing ground. But at present we have no measure of total purchases of farm requisites in Wales and therefore we have no measure of the proportion of that turnover which is being held by the agricultural co-operative movement. For it is possible when total purchases are declining, although the total sales of the movement are also declining, it may be actually increasing its share of the total trade.

Although the tabulated statements of gross profits and net profits shown by societies are of considerable interest to persons interested in agricultural co-operation, they are no guide to trading efficiency owing to the varying nature of the individual businesses and the different policies of the committees of management.

Perhaps the best guide at the present time is the total trade expenses when stated as a percentage of sales. But again we have considerable variation due to differences in services rendered by societies and to costs of financing trade. But as the general principle of the movement is to supply members or purchasers with goods at a minimum increase in price over original cost, the society which is able to sell at a lower percentage increase may be described as the more efficient.

The actual service rendered by a co-operative society to the agricultural community in its trading area cannot be measured by its trading results or balance sheet. A small margin of profits must be earned but a reasonably efficient society operating in an area with the sole object of selling at the lowest possible economic price does materially affect the price at which similar commodities are purchasable throughout that area. If any society succeeds in doing this it can be stated that it is successful and is rendering a service to agriculture of which there is no satisfactory measure.

A COMPARATIVE STUDY OF PRODUCTION ON FARMS IN THE WELSHPOOL DISTRICT OF THE SEVERN VALLEY FOR THE YEARS 1919 AND 1932.

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During 1919 a survey [1] was conducted in the Severn Valley (Montgomeryshire); information was therefore available relating to the systems of farming pursued, stocking of the holdings, together with the amounts of various commodities produced. In 1932 the area was re-surveyed and data were obtained which could be compared with those previously procured, whilst some additional information of a financial nature was obtained. Serious fluctuations in prices occurred in the interval, and farmers attempted to respond accordingly; and the degree, nature and rapidity of such responses are matters upon which information was sought.

Of the 52 farms visited in the two years of survey, 36 holdings remain sufficiently comparable to be dealt with in this study. Of the other 16 farms eight were discarded owing to a change of tenancy within a year of June 1932, while another eight were excluded on the score of considerable change of acreage.

It is thought advisable to group the farms entirely on a size basis, as that was the method adopted in the 1919 Report, and a simple, if not comprehensive, classification is most useful for

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[1] Survey of Severn Valley by J. Pryse Howell. (Unpublished).

forming the primary background of the study. The classification divided the farms into five groups :

Group I	...	0— 50 acres (8 Farms).
Group II	..	50—100 acres (8 Farms).
Group III	..	100—150 acres (10 Farms).
Group IV	...	150—250 acres (7 Farms).
Group V	....	Over 250 acres (8 Farms).

The average acreage for each Group in 1919 and 1982 does not vary very considerably from one period to the other. The largest discrepancy, a decline of 3 per cent. is found in Group IV.

TABLE I.

Characteristics of the Five Groups.

Group	*Acreage.*		*% Arable.*		*% Owner-occupier. 1932.*	*Altitude (1919).*	
	1919	*1932*	*1919*	*1932*		*Simple Average.*	*Weighted Average.*
I	37.0	36.7	20.0	8.9	33.3	386.7	422.6
II	82.6	81.6	25.7	15.7	75.0	369.4	382.5
III	141.3	139.6	21.4	13.8	60.0	373.1	377.0
IV	193.9	188.2	10.4	6.8	12.8	337.1	345.4
V	329.9	329.2	19.0	13.2	12.5	335.6	380.3

It is interesting to note the relation between the average size of farms and the average altitude. In this district it is found that the larger farms are situated on the low land.

The figures of the proportion of land in arable cultivation show that in no group does the 1982 percentage equal that for 1919. The decrease is probably due to the re-assumption of a more normal proportion of arable land after the ploughing-up campaign of the latter years of the war.

TABLE II.

Stocking of Farms. (Average Number per Farm).

Group.		*Horses.*		*Cattle.*		*Sheep.*		*Pigs.*	
		1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
I	....	2.00	3.33	18.85	32.67	39.00	72.00	10.00	22.00
II	....	6.63	4.13	28.01	40.51	103.38	148.61	9.38	12.78
III	....	9.80	7.40	43.40	56.60	152.50	190.60	14.70	12.00
IV	....	10.72	5.72	62.19	80.42	240.70	286.00	38.14	7.70
V	....	21.63	10.13	118.01	125.13	432.30	407.76	16.25	24.13

The numbers of horses have declined in all groups, except the smallest one. The slight increase in the numbers in Group I may be partly accidental owing to the small number of farms in the group; but it must be borne in mind that on these small farms the very considerable enterprise of horse breeding, for the district, can not be carried on to the greatest advantage; as with the small farmer horse breeding is more a hobby than a matter of business.

Under the heading " work horses " are included horses that are used for all working purposes; this naturally includes some of the horses used for breeding purposes to some extent as well. " Other horses " consist of stallions and other horses of various ages which are not used for working at all.

TABLE III.

Horses Carried. (Average per Farm).

Group.	*Work Horses.*		*Other Horses.*	
	1919.	*1932.*	*1919.*	*1932.*
I	2.00	2.00	--	1.33
II	3.88	2.75	2.75	1.38
III	5.50	4.00	3.80	3.40
IV	6.29	4.29	1.43	1.13
V	8.63	5.88	13.00	4.25

The numbers of work horses have not varied to any great extent. When consideration is taken of the fact that mares used for working and breeding have probably decreased in sympathy with the trend in the numbers of those used entirely for breeding, it can be stated that the horse stock has not undergone any appreciable change. There has been a marked decrease, though, in the number of ' other ' horses, except in the case of Group I. Since this heading indicates roughly the extent of the horse-breeding enterprise, no young horses being bought in either year, it seems that the amount of attention given to this enterprise has definitely decreased. The decline in horse-breeding is due mainly to the lack of demand for horses in the towns, since motor vehicles have become popular. Many of the farmers of this district, which has a reputation for horse-breeding, have lost a considerable source of income with the declining demand for good horses.

The sub-heading " cows " includes both cows kept mainly for rearing calves, and those kept for milking; the differentiation between these two classes is by no means precise, especially on

farms where milk production was not a very specialised enterprise. The numbers of cows have increased in all groups, but by no means to an equal degree; in Group III the increase was in the neighbourhood of 3 per cent. while in Group IV (150-250 acres at low altitudes) it was 190 per cent. A more detailed analysis of

TABLE IV.

Cattle Carried. (Average per Farm).

Group.	*Cows.*		*Stock over one year old.*		*Stock under one year old.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
I	3.67	8.67	6.00	16.00	3.68	8.00
II	7.88	16.38	9.38	11.25	10.75	12.58
III	12.10	12.60	16.20	32.00	15.10	12.00
IV	7.43	22.71	15.57	44.00	9.19	13.71
V	16.38	21.38	80.50	83.00	16.13	17.75

these changes will be made when the farms that have specialised in milk production have been segregated.

Stock over one year old represents cattle to be fattened in the following season or which were in the process of being fattened. It is noticeable that numbers of stock in this class have increased, though not to an equal extent in each group. There seems to be some degree of association between the numbers of cows and of stock over one year old; groups which show only a small increase in cows tend to have the largest increase in stock over one year old. On the face of it it would seem that cattle fatteners have tried to intensify this enterprise. The trend, though, may have been exaggerated for two main reasons: first, that owing to the continued slump in fat stock prices during the summer of 1932 many of the animals have been held back in the hope of a rise in prices; and secondly, that farmers may have been buying in younger store stock, and for that reason had more cattle of one year old and over on their farms.

Numbers of store cattle, or stock of less than one year old, show relatively little change. The movements seem generally to be associated directly with the changes in the numbers of cows: the largest increase is found where there is the largest increase in cows. This may be due to the fact that the store stock enterprise has remaineed almost stationary in importance, and the increase shown has been due to heifers kept to replenish the dairy herds.

Since no store sheep are bought in for feeding on these farms, the numbers of ewes give a reliable indication of the extent of the

sheep enterprise. Here again, however, is encountered the difficulty of assessing the effect of the decline in sheep prices during the year 1931-32. On most of the farms a large number of ewes were drafted out after the lambing season, a corresponding number bought in and only a few of the lambs were retained for breeding : most farmers considered the land unsuitable for keeping sheep on the average for more than one year.

TABLE V.

Sheep Carried. (Average Number per Farm).

Group.	*Ewes.*		*Other Sheep.*		*Total.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
I	16.67	25.33	22.33	46.47	39.00	72.00
II	40.00	62.75	63.38	85.85	103.38	148.61
III	59.10	77.30	93.40	113.30	152.50	190.60
IV	91.40	105.00	149.30	181.00	240.70	286.00
V	172.20	157.13	260.16	250.63	432.30	407.76

TABLE VI.

Sales and Purchases of Ewes (1932). (Average per Farm).

Group.	*Ewes bought.*					*Ewes sold.*				
	Number.	*Average price per head.*		*Value.*		*Number.*	*Average price per head.*		*Value.*	
		s.	d.	£	s.		s.	d.	£	s.
I	12.7	42	0	27	1	17.3	35	0	29	18
II	26.9	47	0	63	0	27.1	47	0	64	10
III	62.8	53	0	166	10	68.3	61	0	208	14
IV	70.0	48	0	168	9	101.4	36	0	188	12
V	104.4	42	0	216	6	119.5	39	0	231	14

The sales and purchases of ewes in comparison with the size of the flocks are great. No measure of the " profit " made by the sale of ewes, however, can be given, as no account is taken of the change in valuation of the flocks. There does seem, though, to be an indication that ewes were sometimes sold out at a higher price than that for which they were bought; especially is this so in the farms at moderate altitudes *i.e.*, Group III. It is customary for farmers on these holdings to sell their ewes to the lowland farms after one lambing. This increase in the sale over the purchase price is to some extent masked by the general decline in sheep prices during 1931-32.

Pigs have not been in either year a major enterprise in the economy of farms in this district. It is seen that the numbers of pigs kept have varied considerably. The variations do not seem to follow any very definite trend; there have been increases in some groups, while the numbers in others have declined.

TABLE VII.

Pigs Carried. (Average per Farm).

Group.	*Sows.*		*Other Pigs.*		*Total Pigs.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
I	1.67	4.67	8.33	17.33	10.00	22.00
II	1.25	2.50	8.13	10.28	9.38	12.78
III	2.30	1.70	12.40	10.30	14.70	12.00
IV	5.00	1.29	33.40	6.43	38.40	7.72
V	1.75	3.50	14.50	60.63	16.25	24.13

Production.

The total value of production has declined, largely as a result of changes in prices, but these require analysis with the changes in the nature of the products.

TABLE VIII.

Total Production. (In £'s per Farm).

Group.	*Arable Land.*		*Livestock and Livestock Products.*		*Total Products.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
I	19.2	--	400.0	375.8	419.2	375.8
II	92.7	7.7	630.8	456.6	723.5	464.3
III	64.8	3.4	778.4	541.2	848.2	544.6
IV	51.0	15.9	1138.3	625.0	1189.3	640.9
V	278.0	12.8	1733.0	1137.7	2011.0	1150.5

Some of the farms have specialised in milk production since 1919. In order to define these farms a minimum proportion of 25 per cent. of milk in the total sales in 1932 was taken, because that figure included all farms that appeared to have made a radical change. Seven farms in all come into this category—one from Group I, three from Group II, and one each from the other three Groups of the original classification.

The remaining 29 farms were re-classified on a size basis. The reason for the revision of the classification of these farms was that under the new arrangement each of the new groups

contained a more regular number of farms, and that the acreage limits of each group were more clearly defined when all the farms were arranged categorically. The classification arranged the farms in four groups :

(i) Milk Farms Group (those farms that have specialised in Milk Production).
(ii) Smallest Size Group (0—100 acres).
(iii) Medium Size Group (100—175 acres).
(iv) Largest Size Group (Over 175 acres).

TABLE IX.

Characteristics of Groups. (Average per Farm).

	Milk Farms. Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Number of Farms	7		7		11		11	
Altitude (in feet above sea level)	366		371		346		356	
% Arable Land	17.9	7.8	28.1	17.9	19.5	10.3	16.1	12.4
Rent per Acre (shillings)	28.8	35.6	33.6	34.0	27.0	29.6	28.0	31.0

The most notable change is in the increase in cows in the Milk Farms Group. In other groups cows have tended to increase slightly, but in no very marked degree. Whereas in the Milk Farms Group the number of stock over one year old (fattening stock), have been reduced by about one-third, the numbers in this class have increased consistently in the other groups, the greatest increase is found in the Medium Size Group. In the case of stock under one year old (store and young stock), no material change is to be noted.

TABLE X.

Cattle Carried. (Average per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Cows	7.43	29.57	7.57	8.00	10.91	10.91	13.91	23.09
Cattle over 1 year	20.43	13.57	9.00	11.71	24.91	38.82	67.09	73.18
Cattle under 1 year	10.29	10.29	8.57	11.29	12.54	11.18	15.64	19.09

With the exception of the Milk Farms Group the value of production has decreased by approximately one-half; there is a decrease of 60 per cent. in the Smallest Size Group, while in the other two groups the decrease is 44 per cent.

TABLE XI.

Total Production. (In £'s per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Arable Land ...	42.1	—	95.0	8.6	111.2	3.1	218.9	19.4
Livestock and Livestock Products	847.2	834.0	532.8	217.2	831.1	525.9	1579.0	977.4
Total Production	889.3	834.0	627.8	225.8	942.3	529.0	1797.9	996.8

The market production, that is the sales, of grain have decreased to practically a negligible figure, while clover-seed has decreased to some extent also, except in the Largest Size Group; the explanation of this latter fact is probably that only the largest farms retain a sufficient acreage of arable land to include in it one shift of such a specialised and uncertain crop as clover-seed.

TABLE XII.

Arable Land and Livestock Products. (In £'s per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Arable.								
Clover Seed	—	—	21.3	0.8	17.5	—	9.0	10.1
Grain	42.1	—	73.7	7.8	93.7	3.1	209.9	9.3
Total	42.1	—	95.0	8.6	111.2	3.1	218.9	19.4
Livestock.								
Wool	18.0	6.4	11.4	6.2	26.3	13.0	53.2	16.8
Milk and Dairy Produce	69.9	454.8*	46.9	—	38.7	19.0	121.9	97.9
Total	87.9	461.2	58.3	6.2	65.0	32.0	175.1	114.7

* Mainly Milk.

The value of wool produced has declined in all groups; but to a more marked degree in the Larger Size Groups. Except for the Milk Farm Group, the value of milk produced has declined also. This decline may be attributable to the tendency towards specialisation for milk production, for while the largest producers have definitely increased their output in 1932, in other cases output has diminished.

Livestock contributes by far the largest part of the production. This is the case in all groups in 1919 and all except the Milk Farms Group in 1932.

TABLE XIII.

The Relative Importance of Livestock.

Percentage of Production contributed by :—	*Milk Farms Group.*		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Livestock ...	85.4	44.7	75.6	93.4	81.3	93.4	78.1	86.5
Livestock Products	9.9	55.3	9.3	2.8	6.9	6.0	9.7	11.5
Arable	4.7	—	15.1	3.8	11.8	0.6	12.2	2.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

With the exception of the Milk Farms Group there has been a tendency to concentrate more on livestock production in 1932 than was evident in 1919. In the earlier period the importance of livestock was practically uniform throughout the three size groups, whereas in the later period the smaller groups concentrated more on livestock than the Largest Size Group. This is in part due to the sales of milk which increase the relative importance of livestock products in this group.

The total value has diminished considerably in all groups. As this is the case and the individual components of the total have all diminished also, the comparison of the percentages which each represents of the total is the clearest method of studying the figures.

The production of sheep has been practically of equal relative importance in both years and in all groups.

Cattle show a marked increase, except in the Milk Farms, in 1932 over 1919. This could be caused by two factors: first that the actual production of cattle relative to other livestock had increased, and second that the decrease in pigs had lowered the total production so that cattle are given an increased significance,

TABLE XIV.

Value of Livestock. (In £'s per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Sheep	207.5	137.4	150.6	69.8	248.1	179.1	515.6	218.2
Cattle	343.6	133.1	216.1	133.3	411.4	305.3	730.5	594.4
Pigs	208.5	102.3	107.8	7.9	106.6	9.5	157.8	55.0
Total	759.6	372.8	474.5	211.0	766.1	483.9	1403.9	862.7

Percentage contributed by Sheep, Cattle, and Pigs per Farm.

Sheep	27.3	36.9	31.7	33.1	32.4	36.3	36.7	24.7
Cattle	45.4	35.7	45.6	63.2	53.7	61.8	52.1	68.9
Pigs	27.3	27.4	22.7	3.7	13.9	1.9	11.2	6.4
Total Production	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Since the production of sheep remained practically constant, the increase in the proportion of cattle production is due in some measure to both these factors. The decline in the importance of pigs relative to the whole is not unexpected when account is taken of the numbers of pigs kept on farms in the two years.

TABLE XV.

Pigs Carried. (Average per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Breeding Sows	2.00	8.86	1.14	1.43	3.64	1.64	2.18	2.82
Other Pigs	11.86	19.43	8.00	6.57	21.73	9.91	16.73	14.18
Total	13.86	28.29	9.14	8.00	25.37	11.55	18.91	17.00

In all of the three size groups the numbers of pigs have declined to some extent. The decrease in the numbrs of " other pigs " has contributed mainly to the decline in the total numbers, while the numbers of sows have declined only in one group. This circumstance points to the fact that though the numbers of pigs have declined, the potential size of the enterprise, as represented by the number of sows, does not show any marked diminution,

The Influence of Price Changes in the Estimation of Production.

With the exception of milk, no enterprise shows an increase in value of production in 1932 in any one group. The values of production as stated above do not, however, give an indication of the relative quantities produced; as in a period of low prices a farmer may increase the volume of production on his holding without necessarily increasing the value of it.

In order to obtain some measure of the price variation between the two years, an index number of prices has been constructed [2]. The index number is presented as follows :—

Index of Prices of Products sold off Farms.†
1919 : 100.0. 1932 : 64.84.

The prices in 1932 were on the average a little less than two-thirds of those in 1919. It follows from this that if the values of production were the same in the two years the quantities produced in 1932 would have to be on the average more than one and one-half times those of 1919.

TABLE XVI.

The Index of Physical Quantities by Production.

	1919.	*1932.*
Total Value of Production (£'s per Farm)	1,104.5	499.2
Index of Prices	1,000.0	0.6481
Relative Physical Quantities of Production†	1,104.5	769.9

† Calculated by dividing value of production by indices of Prices.

A comparison of the 1919 and 1932 figures of the value of total production and of the index of physical quantitites, indicates that the decrease in the value of production tends to be exaggerated by the changes in prices. The large fall in the value of production in the three size groups was due more to the fall in prices than to the shrinkage of actual production; for instance, in the Medium Size Group the decrease in the value of production was 44 per cent., whereas the decrease in the quantity of production was only 18 per cent.

[2] The statistical method used in computing this number is based upon Fisher's formula, since that is the most accurate for a comparison of prices in two years only. The prices of the commodities sold off these farms were weighted by the physical quantities produced. The index number is therefore a special one for the prices of commodities produced on these farms, and it should not be construed in any wider sense.

Adjusted Values.

An alternative method of assessing production with the price influence eliminated is, what may be termed, that of the adjusted values. The principle of this method is to estimate all values of production at the price of the base year. Thus the values of a commodity in the given year is divided by its relative price in the base and the given year. This method has the advantage over the physical quantities in that the adjusted values of various commodoties can be compared with each other. This calculation does not claim to forecast the value of production in the given year if prices had remained constant; it is rather the expression of the value of production at a constant price.

TABLE XVII.

Livestock Products.

(Value of 1932 Production adjusted by relative prices. In £'s per Farm).*

	1919.	*1932.*
Average Price of Wool (Pence per lb.) ...	18	7½
Relative Price	1.000	0.417
Average Price of Milk (Pence per gallon: 10.3 lb.)	17½	10¼
Relative Price	1.000	0.585

* For actual value 1932 see Table XII.

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
	£	£	£	£	£	£	£	£
Wool Production	18.0	*15.4*	11.4	*14.9*	26.3	*31.2*	53.2	*40.3*
Milk Production	69.6	*777.4*	46.9	—	38.7	*32.5*	121.9	*167.4*
Total Livestock Production	87.6	792.8	58.3	14.9	65.0	63.7	175.1	207.7

Comparison of Production on the Basis of Adjusted Values.

The production of wool has not decreased and milk production in the three size groups, too , has not changed to the extent indicated previously. With the exception of the Smallest Size Group it appears that the small producers of milk have practically maintained their output. The increase is partly the result of farms selling milk in 1982 which did not sell milk in 1919.

Arable land production has declined to a small fraction of its 1919 volume consistently throughout all groups. The sale of clover seed has been reduced to an almost negligible amount, and only in the Largest Size Group is it nearly equal to that of 1919. The sale of grain has declined to an even more marked degree. It has been shown [3] that the proportion of arable land has decreased on the average by about one-half. The contraction in the arable acreage accounts in some measure for the decrease in the sale of arable products, but it can not account for it entirely.

TABLE XVIII.

Arable Land Production.

(Values in 1932 adjusted by the relative prices. In £'s per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Clover Seed ...	—	—	21.3	*0.6*	17.5	—	9.0	*7.2*
Grain	42.1	—	73.7	*15.9*	93.7	*6.8*	209.9	*19.0*
Total Arable Production	42.1	—	95.0	*16.5*	111.2	*6.8*	218.9	*26.2*

In the case of the production of grain, the decrease in the percentage of arable land is probably not the main cause of the decline in production. The prices of purchased feeding stuffs have until recently remained relatively high, and the prices of grain have been low. The heavy decline, then, in the volume of grain sold is probably for the most part due to the increased use of crops for feeding purposes.

TABLE XIX.

Livestock Production.

(Values in 1932 adjusted by the relative prices. In £'s per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Sheep	207.5	*252.8*	150.6	*128.4*	248.1	*329.1*	515.6	*392.3*
Cattle	343.6	*159.7*	216.1	*160.0*	411.4	*366.4*	730.5	*713.4*
Pigs	208.5	*201.5*	107.8	*15.6*	106.6	*18.7*	157.8	*108.4*
Total Livestock Production	759.6	*614.0*	474.5	*304.0*	766.2	*714.2*	1403.9	1214.1

[3] See Table IX.

In the Milk Farms Group the value of cattle production has declined, while that of sheep has increased slightly. The production of pigs in the Milk Farms Group has remained practically stationary, whereas in all other groups it has very materially decreased. This maintenance of the pork and bacon enterprises against the total decline of these farms may well be traceable to the increase in milk production, and the joint nature of the two enterprises.

In the other three groups there has been a decline in livestock production, the most marked change (of 35 per cent.), being in the Smallest Size Group. The unusually heavy decrease in this latter group is mainly attributable to the decline in pig production; this section makes up more than one-half of the total. The marked contraction, then, in the Smallest Size Group may be of a temporary nature, owing to the continued low price of pigs, which had led to the slowing down of this branch of production until prices recover. It should be noted that although the number of other pigs as shown in Table XV have declined, the numbers of sows, and therefore the potential productivity of the enterprise, have increased slightly. It is significant, however, that in this group there has been an appreciable decline in cattle production. This may well be a contraction of a more permanent nature, and be due to farmers definitely taking steps to reduce their production.

In the Medium and Largest Size Group the sum of sheep and cattle production has not changed very materially; it is true that in the former group there is an evident decline, but then it must be remembered that the acreage of holdings in this group has declined by 3 per cent.

TABLE XX.

Summary of Production.

(Values in 1932 adjusted by relative prices. In £'s per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Livestock ...	759.6	*614.0*	474.5	*304.0*	766.1	*714.2*	1403.9	*1214.1*
Livestock Products	87.6	*792.8*	58.3	*14.9*	65.0	*63.7*	175.1	*207.7*
Arable	42.1	—	95.0	*16.5*	111.2	*6.3*	218.9	*26.2*
Total Production	889.3	*1406.8*	627.8	*335.4*	912.3	*784.2*	1797.9	*1448.0*

The volume of production has tended to decrease, but it is evident that it has not decreased to the extent shown in the comparison of values of production irrespective of adjusted values. The Milk Farms Group is the exception to the general lowering of output; in this group farmers have effected an increase in production of some 58 per cent.

Production in Relation to Expenses.

The survey of 1919 was not directed to discovery of profits of farming. Expenditure covers only the main items, and the present comparison is limited to these.[4] The charge for labour is on the average the heaviest item. Rent per farm increases progressively in importance from the Smallest to the Largest Size Group. The proportion that the purchase of feeding stuffs bears to the whole remains fairly constant throughout the three size groups, except that in the Milk Farms Group 1932 it is exceptionally heavy.

TABLE XXI.

The Principal Items of Expenses.
(Expressed as % of Total Expenditure; average per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Rent	31.4	31.7	31.3	32.5	36.0	36.8	37.1	47.9
Labour	40.9	31.2	45.1	45.7	41.8	36.3	29.4	28.0
Feeding Stuffs	22.9	33.9	17.8	18.8	18.4	21.8	29.7	20.5
Manures	4.8	3.2	6.5	3.0	3.8	5.1	3.8	3.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				(In £'s per Farm).				
Rent	165.0	214.9	121.6	122.5	201.0	225.7	423.1	453.4
Labour	214.5	211.4	174.9	172.4	283.4	222.3	334.8	265.0
Feeding Stuffs	120.2	229.2	66.4	70.9	102.8	133.8	339.0	194.7
Manures	25.1	21.9	25.3	11.8	21.7	31.3	43.4	33.9
Total	524.8	677.4	388.2	377.1	558.9	618.1	1140.3	947.0

[4] Expenses comprised of Purchases of Feed and Manures, charges for Rent and charges for Labour. Charges for Rent were estimated in the case of Owner-occupiers from rents of similar tenant-farmed holdings. Charges for Labour were calculated regardless of whether the labour was hired or supplied by the family. In the case of family labour, the assumed wages paid were taken at the current rate for hired workers. No charge was made for wages of management; it was assumed that management of farms in the two smaller size groups occupied the time of one man, and in the Largest Size Group and the Milk Farms Group it occupied the time of 1.5 men.

In the Milk Farms Group the total charges have increased by 29 per cent. Two-thirds of the increase is accounted for by purchase of feeding stuffs. Such is the natural consequence of the farms turning from Cattle and Sheep to Milk Production. The rent payments of the farms in this group have accounted for most of the remainder of the increase in the total expenditure.

Rentals have shown no tendency to decline. The total payment for rent on farms in all groups has increased. The greatest increase in this item is in the Milk Farms Group; in the three size groups there has been a tendency for rent payments to increase to a greater extent in the larger than the smaller groups.

TABLE XXII.
Rent. (£'s).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Rent per Farm	165.0	214.9	121.6	122.5	201.8	225.7	423.1	453.4
% Change in 1932	—	30.2	—	0.7	—	1.2	—	7.1
Rent per 100 Acres	134.5	162.8	166.3	172.4	137.9	152.5	140.6	154.2
% Change in 1932	—	21.0	—	3.7	—	10.5	—	9.7

The general increase in rentals in the first place, is probably due to the lag between agricultural prices and the amount of this payment; in 1919 rents had probably not risen relatively as high as prices, but rents and rental charges rose in the interval, and in 1932 they still remained at a comparatively high level; thus the rents in 1932 may be higher than in 1919, while the level of agricultural prices is considerably lower.

It does seem that the increases in the rents are related to the numbers of owner-occupiers; for as the numbers of owner-occupiers decrease so the increase in rent becomes greater. In the case of the Milk Farms Group the rents have risen considerably more than in the other groups, both in rents per holding and per 100 acres. There appears to be two reasons for this notable increase: first, that farmers who specialised in Milk Production have required or been able to increase the size of their holdings; the increased demand for land has probably increased the rents the owners demanded for it; and secondly, that a large part of this increased demand was for the better land, the rent of which would normally be above the average of the original Milk Farms.

TABLE XXIII.
Labour and Wages Charges.

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Expenditure on Wages (in £'s per Farm)	214.50	211.40	174.90	172.40	233.10	222.30	334.80	265.00
"Man Units" employed (per Farm)	3.30	2.71	2.69	2.21	3.59	2.88	5.15	3.43
Expenditure on Wages (in £'s per 100 Acres)	174.40	160.10	238.80	242.80	158.80	150.20	110.90	90.10
"Man Units" employed (per 100 Acres)	2.65	2.05	3.72	3.11	2.44	1.95	1.71	1.16

Labour.

The charges for labour have decreased in all groups.[5] This item is calculated on the assumption that one "man unit", whether of hired or family labour, receives the standard minimum wage in cash. The decline in the cost of labour is not rêmarkable as the rates of wages have fallen, but amount of labour has also diminished. It is probable that this item is the one that rankles most in the minds of farmers; this is not only because wages are relatively high, but that the farmer thinks that they are unjustly high, and thus makes him consider the reduction of his labour expenses.

There appears to be a relationship between the decrease in charges for labour and the extent to which family labour is employed: as the proportion of family labour decreases so the reduction of the amount of wages paid in 1932 over 1919 increases. Farms employing a large proportion of hired labour have been able to economise in this item to a greater extent than those farms with a high proportion of family labour. These figures of the payments in wages, though, are in some respects empirical, since they are calculated on the assumption that family labour is paid the full wage of the hired worker in cash. This is not, generally speaking, the case as members of the farmer's family do not usually receive wages in cash regularly. The more "family" farmers have probably economised in their labour expenses by paying their relations at a rate lower than that of the hired

[5] See Table XXI.

worker, and by taking smaller income for personal purposes from these farms.

TABLE XXIV.

Family Labour and Expenditure on Wages.
(Average per Farm).

Proportion of Labour Supplied by the Family.	*0—35 %*	*36—55 %*	*Over 56 %*
Number of Farms	10	8	11
Size of Farms (1982)	229.6	175.7	149.0
Expenditure on Labour (1919)	295.1	243.9	294.4
Expenditure on Labour (1932)	228.2	196.4	283.1
Decrease in Charge of Labour (% of 1919)	22.7	21.5	3.8

Production in Relation to Expenses.

The statement of production in terms of units of expenditure would, on the face of it, appear to be an assessment of the efficiency of farms. This, however, is not true, as agricultural production does not operate to any great extent under constant returns; each unit of input does not yield equal amounts of output. But unless detailed cost accounts are available or elaborate statistical methods are employed, there is no means of assessing the real efficiency of farms.

In the first place production in terms of the total expenses should be studied and Table 25 summarises this comparison. In all groups the total production per unit of total expenses is lower in 1982 than it was in 1919; especially is this so in the smallest and the medium size groups. In these two groups the proportion of owner-occupiers and the proportion of labour supplied by the family is higher than in the other two size groups; and for that reason the calculated charges of rent and wages are higher than the actual cash transactions made by the farmer. Nevertheless, it is seen that the value of production per unit of total expenses has decreased.

In the case of adjusted production per unit of total expenses it is seen that only in the Smallest and Medium Size Groups are the 1982 figures considerably below those of 1919. The Milk Farms Group has increased very appreciably the volume of production per unit of outgoings, while the Largest Size Group remains practically the same in the two years.

The value of production per £100 expended on rent has declined considerably in all groups. The three size groups seem to

TABLE XXV.

Actual and Adjusted Production per Unit of Total Expenses.

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Actual Production	889.3	834.0	627.8	225.8	942.3	529.0	1797.9	996.8
Total Expenditure	524.8	677.4	388.2	377.1	558.9	613.1	1140.3	947.0
Total Production per £100 of Total Expenditure	169.5	123.1	161.7	59.9	168.6	86.3	157.7	105.3
Adjusted Production	889.3	*1407.1*	627.8	*335.4*	942.3	*784.2*	1797.9	*1448.0*
Total Expenditure	524.8	677.4	388.2	377.1	558.9	613.1	1140.3	947.0
Adjusted Production per £100 Total Production	169.5	*207.7*	161.7	*88.9*	168.6	*127.9*	157.7	*152.9*

have suffered practically an equal fall in production, while in the Milk Farms Group the production has declined much less.

In considering the adjusted production per £100 expended on rent it is seen that whereas the Milk Farms Group is still in the most advantageous position, the Smallest Size Group has taken

TABLE XXVI.

Production per Unit Rent Charge.

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Total Production per £100 Rent Charge	539.0	388.1	516.2	184.3	468.8	234.3	424.9	219.8
% Change in 1932	—	—28.0	—	—64.3	—	—50.0	—	—48.2
Adjusted Production per £100 Rent Charge	539.0	*654.7*	516.2	*273.8*	468.8	*347.5*	424.9	*319.8*
% Change in 1932	—	+21.4	—	—47.0	—	—25.9	—	—25.4
% Owner-occupiers	—	42.9	—	85.7	—	68.6	—	9.1

by far the greater decline in the size groups. This is in some measure, probably, due to the high proportion of owner-occupiers in this group; the payment on rent in this group is probably not as high as the estimated expenditure.

It is significant that only in the Largest Size Group does the production per £100 of Feeds and Manures purchased in 1932 approach that in 1919. This is due not so much to the expenditure on this item being exceptionally low in this group for 1932 as compared with other groups, but that there has been a reduction of about 67 per cent. in this item of expenditure in 1932 as opposed to 1919. The adjusted production is seen to have materially increased in the Largest Size Group in 1932. The contraction in the adjusted production in the Milk Farms Group is considerably less than in the two smaller size groups.

TABLE XXVII.

Production per Unit of Feeding Stuffs and Manures Purchased.

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*
Production per £100 Feeds and Manures Purchased	612.0	332.1	684.6	277.1	756.8	320.4	470.1	436.0
% Change in 1932	—	—45.7	—	—59.5	—	—57.7	—	—7.3
Adjusted Production per £100 Feeds and Manures	612.0	*560.4*	684.6	*408.0*	756.8	*474.9*	470.1	*633.4*
% Change in 1932	—	—8.4	—	—42.6	—	—37.2	—	+34.7
% Decrease in Arable Acreage	—	58.2	—	13.7	—	46.9	—	25.1

The superior position of the Largest Size Group in respect of this aspect of production is probably that the cattle fattening enterprise as practised in this district gives the largest volume of production in relation especially to the expenditure on feeding stuffs; cattle fattened mainly on grassland gives a larger return for the amount of feeding stuffs used to finish the fattening process. The arable acreage, too, in this group is by far the largest; appreciable amounts of grain were sown for consumption on these farms. This reduces the expenditure on feeding stuffs, and gives a higher return per unit of feed bought. In the case of milk production considerable quantities of purchased feeding

stuffs must be used if high production per cow is required. The Milk Farms have increased the production per man in 1932 considerably. The total production of the three size groups is notably lower in the earlier year than in the latter. It is significant that the adverse margin between the total production per man in 1919 and 1932 decreases with the increasing size groups; this seems to be associated with the proportion of labour supplied by the family. It is probable that on farms with a large proportion of hired labour, farmers have been able to re-organise their labour resources to better advantage than on those with a high proportion of family labour; it must be remembered, too, that the groups with a high proportion of hired labour have a larger total labour force than other groups,[6] and therefore the re-organisation of labour can be done more effectively. With the exception of the Smallest Size Group, the adjusted production per man has tended to increase. This trend is probably the result of economies being made in the use of labour; when the labour force is reduced the remaining men are employed for a longer time on the jobs that yield the greatest return.

TABLE XXVIII.

Production per Man Employed. (In £'s per Farm).

	Milk Farms Group.		*Smallest size Group.*		*Medium size Group.*		*Largest size Group.*	
	1919.	*1932.*	*1919.*	*1932.*	*1919.*	*1932.*	*1919.*	**1932.**
Production per 'Man Unit' Employed†	269.5	307.7	233.4	102.2	262.5	185.6	348.9	**292.3**
% Change in 1932	—	+11.2	—	—56.2	-	—29.8	—	—6.2
Adjusted Production per 'Man Unit' Employed	269.5	*542.8*	233.4	*151.8*	262.5	*275.[illegible]*	348.9	*424.6*
% Change in 1932	—	+101.4	—	-34.8	-	+4.8	—	+21.7
% Supplied by the Family	—	20.3	—	45.7	—	25.3	—	19.0

† 1 "Man Unit" was taken as the equivalent of 1 full man, 1.7 boys under eighteen, 2.2 women working full time.

Conclusion.

During the period 1919-1932 there have been some very notable changes in the agricultural systems of the farms studied. The first outstanding change is in the contraction of the arable

[6] See Table XXIII.

acreage; on these thirty-six farms approximately 400 acres have gone out of arable cultivation. Even allowing for the contraction in the total acreage of the farms of some 30 acres, it is seen that the decline in arable is very significant. The chief factor responsible for this decline is probably the fall in price of cereals, both absolutely and relatively to those of many animal products. But though the arable acreage has declined by 38 per cent. the sales of grain, excluding clover seed, have decreased by 95 per cent. It seems, therefore, that either the productivity of the land has seriously declined, or a greater proportion of cereals grown on the land has been used for feeding purposes. From information gathered on the 1932 survey it appears that the latter supposition is the true one; there was no indication in the district of a lowering of the intensity of farming, but many farmers said that they were using a great deal more home grown foods in their rations. It may be said, then, that on these farms arable land production has changed to a large degree from an independent enterprise to a more subsidiary one, the purpose of which is mainly in providing cheap feeding stuffs for the various livestock enterprises.

With the decline in cereal growing an increase in livestock enterprises is seen. The numbers of cattle on these farms have increased by some 600 head and sheep by 1,100 head; the comparatively small pig enterprise, however, shows no increase in the numbers of animals carried. But more significant still is the increase in Milk Production. In 1919 there were approximately 30,000 gallons of milk sold off these farms; in 1932 there were over 105,000 gallons. This big increase, like that in other livestock enterprises, has been stimulated mainly by the decrease in grain sales and of arable land.

With this increased concentration on livestock rather than cereal production is found a decrease in the numbers of persons engaged in agriculture; in 1919 there were a total of 179 persons including the farmers themselves, engaged in the working of these farms, while in 1932 there were only 149 persons. It should be noted, too, that the estimate of total adjusted production, which represents the relative physical quantities, indicates a decline; in 1919 it was £42,762, and in 1932 £36,780.

Such an estimate, however, cannot be exact, for there is no exact measure of change where, say, a decrease in cereals and an increase in milk is involved. On the basis of the total changes, the value of output per person engaged over all the farms, when values are taken at the same level in each period, has increased.

In studying the value of production, it may be stated that the value has tended to decline in all groups. The volume of production, on the other hand, has not decreased to such a marked extent; in the Milk Farms Group the volume of production, as measured on the adjusted price basis, was considerably

	Persons engaged.	*Total Adjusted Value of Production.*	*Production per Person. (approx.).*
		£	£
1919	179	42.762	238
1982	149	36,780	247

higher in 1982 than in 1919. The only group that showed a very marked decline was the Smallest Size Group. It appears, then, that the farmers who turned to milk production found it advantageous to increase their output, whereas farmers practising other systems found the most remunerative policy was to decrease their production to some extent. This in some measure is true, and milk production recently has had an optimum intensity above probably those of many other enterprises; but the increase in production of the Milk Farms may not be entirely disconnected with the decrease in other groups : the increase in acreage in the Milk Farms Group was of the better land; this new land was taken to some extent from other holdings, and these other holdings became correspondingly poorer as regards quality of land.

Such diminution of production as has occurred is not associated with a corresponding reduction in expenditure. The item of expenditure which has probably been the most important factor in limiting production is the purchased feeds and manures. It is in the purchase of feeding stuffs that the least economy is effected; the notable exception to this statement is the Largest Size Group. The increase of nearly 100 per cent. in the purchase of feeding stuffs in the Milk Farms Group has been justified by the change in the system of farming on these farms. The high expenditure in the Smallest and Medium Size Groups seems to be incompatible with the extent of production. Some effort to reduce these purchases seems to have been made by the use of more feed grown on the farms. It is significant that in the group with the largest increase in expenditure on feeding stuffs (the Medium Size Group, with an increase of 38 per cent.) there is the greatest reduction in arable acreage.

RETAILING OF MILK BY PRODUCERS IN THE CARDIFF AREA.

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During 1933 an inquiry was made into the problems relating to the milk supply of Cardiff. The investigation as a whole was rather comprehensive as it included not only the business of wholesaling and retailing fresh milk in the city, supplies of tinned milks, cream, milk powders and other kinds in condensed form, but the nature of the supplies to hospitals, hotels, cafes and other institutions buying semi-wholesale was also investigated. In addition, the consumption of milk and of some milk products was studied whilst factors closely related to the main problems, such as road and rail transport, were included in the inquiry.

There is, however, one aspect of the milk business of most cities, namely the work of the producer-retailers, which stands to some extent by itself. This business is peculiar in some respects and is different from that carried out by city retailers. It is generally considered that farmers doing this work produce the whole or the greater part of the milk which they sell and that they conduct their business through all the processes that exist between production and the final disposal of the milk to the consumer. Nevertheless, the businesses of producer-retailers can be divided into two almost separate and distinct parts; (*a*) that of milk production, and (*b*) that of processing and disposal. In order to include the whole of the business activities of the producer-retailers it was necessary to obtain information relating to both aspects of their work.

There is no clearly marked zone immediately outside the city in which the farms producing milk for direct sale to consumers are situated. Some of the farms visited were as far as 16 miles from the city, whereas 6 to 8 miles was quite common. There were other farms situated much nearer to the city which were producing milk but for wholesale disposal. Others were devoted to mixed farming although many of them appeared to be quite suitable with regard to land and buildings for the direct retail sale of milk. It was quite evident from the outset that proximity to the city was not the most important factor in the distribution of farming systems in the area investigated.

It appears that the personal inclination of the farmer, perhaps in some cases based on previous experience and training,

was of considerable importance in determining the use of farms for this particular type of business in the neighbourhood of the city.

Several enterprises enter into competition with milk production for land on the outskirts of the city, and close to the city this competition becomes rather intense. Market gardening can be included in this category particularly so in the immediate vicinity of Cardiff. Land is generally used very intensively under this system of farming and the value of the output per acre is usually comparatively high and moreover, when a good market for the produce is adjacent, relatively high rents are common. The influence of this factor was conspicuous, as the high rents paid for most of the farms necessitated the intensive use of land. Poultry farming is also to some extent coming into competition with milk production and the latter may gradually move further afield where rents are lower; the use of motor vans will, however, to some extent, offset the disadvantage of longer distances. In general, dairy farms were heavily stocked and the outlay on purchased feeds was high, as farmers endeavoured to obtain a heavy output from their holdings.

For some considerable time preceding this enquiry the milk market in Cardiff had been in rather a chaotic state. It appears that something in the nature of a "milk price war" had prevailed. A considerable amount of under-cutting of prices had been prevalent, and during September, 1933, although the established price was supposed to be 6d. per quart many retailers were selling at 5d., others at 4d. and even at 3½d.

Owing to the low prices obtainable for most classes of agricultural products in recent years, many farmers turned to milk selling as a way out of their difficulties. The great increase in the number of suppliers inevitably gave rise to some difficulty regarding the disposal of the milk, as at the time there was no decrease in the number of city retailers. It was reported that during 1932 and the early part of 1933 there was some increase in the total number of milk vendors in the city and this was not entirely due to the increase in number of producer-retailers. Competition for customers became keener with the resultant cutting of prices. Many farmers were quite frank on this point and admitted quite openly that they set out to " build up " a round in the city and, to accomplish that end, they knew that the cutting of prices and the hawking of milk was the only alternative to buying a round; and a large number of the rounds at present held by producer-retailers were obtained in this way. Several of these

farmers did not wish to continue in the producer-retailer business for any length of time, they looked upon it as a way out of temporary financial difficulties and would be only too glad to resort to other systems of farming when prices appear to justify the change. They hoped, however, to sell the rounds which they had built up and in that way recover any losses they had suffered in the initial stages when they had cut prices in order to gain a foothold in the trade.

Production : Farms under 50 Acres.

In view of the fact that many of the producer-retailers in the area investigated did not specialise in milk production it is not surprising to find several of the farms somewhat highly diversified. In the smallest size group, *viz.* under 50 acres there are 17 holdings—these vary between 13 and 47 acres, seven of these farms had some land under arable cultivation but on the whole the arable area only amounted to 5.5 per cent. of the total. It was not uncommon to find, on the smaller holdings, some market gardening combined with the milk business. This was especially marked in cases where a comparatively large supply of family labour was available. Frequently, the fruit and vegetables produced were taken daily with the milk and sold on the rounds in the city. On some holdings, especially where motor vans were used, it was difficult to state which was the more important

TABLE I.

Producer-Retailers Grouped by Size of Farm.

Area.	*Farms*	*Average Size.*	*Grass.*	*Arable.*	*Rent and *Rates per Acre.*	*Cows per farm.*	*Daily Sales of Milk per farm.*
Acres.	*No.*	*Acres.*	%	%	£ *s. d.*	*No.*	*Gallons.*
0—49	17	28.3	94.5	5.5	3 2 2	9.8	22.8
50—99	14	72.4	95.0	5.0	2 18 0	20.8	35.8
Over 99	10	153.8	89.1	10.9	1 14 1	26.5	41.7
Average	41	74.0	92.0	8.0	2 6 6	17.6	32.0

* Rates have been included in this statement because they are universally regarded by farmers as an item of farm expenses, although rates are not paid on land or farm buildings and are only paid on the house. In some of these cases, and in a relatively high proportion of the cases of small farms, the " dairy " or room used for the storage or treatment of milk is physically a part of the house and rateable value (and therefore rates) is to some extent influenced by this condition. Rates on the dwelling-house may be regarded as an item of expenditure in living or consumption, and not as a business or production expenditure, but are not so regarded by farmers.

business. In such cases the cost of upkeep of the van was distributed between the two enterprises. But for purposes of calculating the actual cost of milk delivery some records had to be omitted in view of close association between two enterprises, to attempt allocation would amount to making entirely arbitrary separations where none could be made with certainty.

On the holdings under 50 acres it was found that rents were comparatively heavy; rent and rates together varied between 25s. 11d. and 186s. 7d. per acre, and were over £8 per acre in nine out of the 17 cases, whilst only on four holdings did they fall below 50s. an acre.

The average number of cows kept in milk varied between 5 and 14; in general more cows were kept in winter than in summer, supplies of milk being maintained in the autumn and winter largely by the purchase of cows in full profit. Five of these seventeen farmers had no income from other livestock enterprises and can be considered as specialising in milk production as far as livestock is concerned. The others had some livestock other than dairy cows on the holdings, sheep in one case, pigs in another, whilst the third kept poultry, but on none of the above mentioned 8 holdings were any calves reared. On the remaining 9 farms dairying was the main enterprise but young stock was reared; the heifers being required for replenishment of the herds whilst stock not so required were sold either in store or fat condition.

The average daily sales per farm were as follows: May 28.7 gallons, August 22.0 gallons, December 22.1 gallons, and actual quantities ranged between 11 and 61 gallons. Five farmers, however, sold some milk wholesale, the average quantity being 5 gallons per day, consequently the range in retail sales was between 11 and 50 gallons, with an average of 19.4 gallons.

Farms between 50 and 99 Acres.

In this Group there are 14 farms. On the average the arable area forms a smaller percentage of the total than in the first group; some arable land, however, was found on 9 holdings but of the total area covered by this group only 5.0 per cent. was tilled. The arable land is mainly devoted to the production of food for consumption by farm stock rather than for direct sale in the form of market garden produce. In consequence this branch of farming enters as part of the work of milk production and is not a separate business,

Rents per acre were on the whole lower in this group, but rent and rates ranged between 28s. 6d. and 105s. 2d. and amounted to over £8 per acre in 7 cases whilst on only 5 holdings were they below 50s. per acre.

The number of cows in milk ranged between 10 and 40 per holding; again farms were stocked slightly heavier with milk cows in winter than in summer. Only 2 farms specialised in milk production to the extent of keeping no other class of livestock, the remaining 12 varied somewhat in their systems, but on all of them some calves were reared and on these holdings herds were gradually replenished in this way. Of these 12 farms some cattle fattening was carried out on 4; one farmer kept sheep also; whilst another had some sheep and pigs on his holding.

Sales of milk between the seasons of the year show the same general variation as in the first group. In May average sales per farm amounted to 36.9 gallons, in August to 33.4 gallons and in December to 35.1 gallons. Six of the farmers, however, were regularly selling milk wholesale in addition to that disposed of retail and the quantity sold in bulk varied between 8 and 20 gallons a day for these farms. As a result, the average daily retail sales amounted to only 30.7 gallons. A very wide variation in the quantity of milk sold off farms is found in this group, the smallest supplier averaging only 15 gallons whilst the largest had 59 gallons daily. The divergence in sales of milk is much greater than in the size of the herds.

Farms over 99 Acres.

Ten farms are included in this group. Over the whole the the arable area amounted to just over 1-10th of the total and individual holdings showed variations of between 0.5 per cent. and 31.2 per cent. of their total area. Although the land under tillage on these comparatively large holdings was proportionately greater than on the smaller ones there was no holding extensively used for market gardening and the produce raised was mainly for consumption by the farm stock.

Rents are again somewhat lower, rent and rates ranged between 21s. 9d. and 55s., but in only one case did they exceed 50s. per acre whilst on 7 holdings they were below £2 an acre.

Dairy herds varied in size between 10 and 68 cows and, in accordance with conditions on both the other groups, a heavier complement of cows was kept in winter. On the average it was some 2 cows per herd greater than during the summer. Only one of these holdings specialised in dairying to the extent of

keeping no other class of livestock. Nine of the farmers reared calves for herd replenishment whilst two of these endeavoured to limit rearing as far as possible to actual herd requirements. Of the remaining seven holdings four kept sheep as a supplementary enterprise, another kept some sheep and pigs, another sheep and feeding cattle, whilst the remaining one had sheep, pigs and feeding cattle present on the farm.

Average daily sales of milk per farm in the three months were as follows : May 42.4 gallons, August 45.2 gallons, December 41.5 gallons. Three of the farms, however, were engaged in the wholesale trade as well; one of these disposed of as much as 80 per cent. of its supply wholesale, whilst another only sold about half of its milk retail. The actual quantities going into the wholesale trade varied between 12 and 26 gallons, with an average of 21 gallons per holding.

The retail trade itself was as low as eight gallons per day in one case, whereas, at the other extreme it reached ninety gallons. Some of these farmers were attempting to build up rounds and hoped to be able to divert larger quantities into the retail market at a later date. In the early stages of the business only comparatively small quantities were being taken directly by consumers, but by further efforts farmers hoped to increase the number of customers and supplies of milk would be obtained by selling less in the wholesale market.

Milk production is generally more intensive on the smaller holdings, as the dairy cows are more frequently the sole livestock present; the high rents paid on such holdings demand that enterprises be as directly productive as possible and that the rate of turnover of capital be rapid. The larger farms are more diversified; in the majority of cases calves are reared and on several holdings other stock is kept with the result that the problems of retailing get relatively less attention.

Balancing of Supplies.

Records were obtained from thirty-six farmers regarding the way supplies of milk were arranged to meet the variable requirements of the retail rounds. Demand for milk fluctuates between different days of the week and between the seasons of the year. Sixteen bought from wholesalers to meet sudden and short period increases in requirements as, *e.g.*, on Sundays; they, however, bought in cows to maintain supplies between the seasons, if necessary. Six always met additional requirements without recourse to wholesalers. These kept a sufficient number

of cows to meet peak demands and endeavoured to arrange the calvings to meet the seasonal fluctuations in demand. Thirteen always balanced supplies from wholesale sources.

Amongst the thirty-six cases fourteen farmers sold in bulk milk that was not required in the retail trade. But the general problem of balancing supplies must be considered in relation to the system of farming pursued. When it is borne in mind that only 19 per cent. of the holdings were exclusively engaged in milk production to the exclusion of other classes of livestock, and that 73 per cent. of the farms reared calves, it is evident that in the majority of cases an outlet for any surplus milk was available.

The women folk on these holdings, however, are not keen on converting the surplus milk into other saleable products. They claim that the handling of small and occasional quantities does not justify the labour involved. Utensils have to be kept for the purpose and a supply of the essential ingredients for processing must be stocked. To make a few pounds of butter at irregular periods involves far more time and expense per unit of product than the regular making of large lots and the final product is often not as good. It is not surprising, therefore, that butter was made on only 14 per cent. of the holdings. On three of the specialised farms an endeavour was made to avoid producing a surplus of milk, accommodation milk was bought when required. The others dispose of what surplus they have in the wholesale market, as they have no facilities for conversion. On some of the diversified holdings farmers attempted a little conversion, but principally for home consumption. Six farms report making butter, eight prepared some clotted cream, but only two made cheese. No case was found where the complete conversion of large quantities was attempted; many farmers fed whole milk to the calves when it was plentiful, others, however, considered this uneconomical and only gave the calves the skim milk. On the holdings, where the latter method is followed, if comparatively large quantities of surplus milk are available and the skim milk is not required for stock feeding, the milk is disposed of through wholesale channels.

Less flexibility was apparent on the smaller holdings; here an endeavour was made to keep as near as possible to the requirements of the retail trade and any balancing, if only comparatively small quantities were required, was done through the wholesalers, but when home production threatened to be below requirements for a length of time the matter was remedied by the purchase of dairy cows. On the larger holdings the farmers were by

no means as anxious about equating production and retail demand; in general a surplus was produced, but it was by no means invariably looked upon as such, but rather in the nature of a reserve supply, to be encouraged as much as possible into retail channels.

The Retailing Aspect of the Business.

The other part of the producer-retailers' work is its transport to the city and its disposal to customers. As there are differences in the costs of producing milk between farms as a result of variations in methods and systems of farming, size of businesses, and differences in managerial efficiency; in the same way it may be anticipated that all farmers are not incurring the same costs in the retailing of their milk.

Complete information was obtained relating to investments in processing plant and in vehicles,[1] whilst the data necessary for the calculation of delivery costs was also secured. For the purposes of analysis, the businesses are grouped on the basis of those factors which appear to be of greatest importance in accounting for the wide difference in costs. All farms are not similarly equipped, even those handling the same gallonage showed wide variation in the quantity and quality of the dairy utensils used. Nevertheless, the groups are sufficiently large to give the figures statistical significance and the results depict the conditions that pertain to the producer-retailers' businesses in the Cardiff area.

In assessing total costs of delivery labour has been charged at the rates of wages set out by the Glamorgan Agricultural Wages Committee. All the work of retailing is not paid for according to these rates as part of it is done by the farmers themselves or by members of their families. Moreover, it is customary for farmers to engage boys to aid them in retailing.

There are two principal methods of delivery, horse-drawn floats and motor vans, but in some cases cycles are used to aid in the work in those businesses which use floats. In such cases the capital cost of the cycles is taken into consideration. Some farmers deliver to a depot the milk which they sell wholesale as they proceed on the retail round. It is impossible to allocate the total cost of transport of milk between these two classes, therefore any additional cost arising from the handling of the wholesale supplies will be included, but in many cases the retail sales

[1] The term vehicles includes floats, vans, cycles or motor cycles, and for farms using horse-vehicles the horses also. Both as regards "capital" and "'cost per gallon" the item "vehicles" includes horses where these are used.

are not entirely independent of the wholesale supply especially when only that which is surplus to the retail requirements is disposed of in bulk.

In calculating the upkeep cost of vehicles, all outlays made in connection with them was included, and in addition, depreciation was charged in all cases. Interest on the capital investment, however, was not included as an expense. Some difficulty arose in a few cases where the vans were only partly used for the work of milk delivery; but an attempt was made in such cases to apportion the total cost, amongst the enterprises making use of the vans, on the basis of time used. On a few farms, however, the separation could not be made satisfactorily, as the work of milk retailing was inextricably mixed up with the transportation of other commodities produced on the farms, and records from such holdings were in consequence omitted from the analysis.

Farms using floats often presented another kind of difficulty; although in general the float itself was not used for purposes other than milk retailing, the horses were in some instances employed on other work. In such cases again total costs were allocated, and only that part properly ascribable to the milk business was charged against it. Some of the food consumed by the horses was produced on the farms, but on most holdings it only amounted to hay and pasture; all foods therefore excluding grass were charged at market values whilst grazing was included at the rental value of the land plus an appropriate sum to cover overhead expenses.

Retail Rounds between 10 *and* 19 *Gallons.*

Seven farms fall into this group, their daily sales range between eleven and sixteen gallons, with an average of thirteen gallons. Six farmers used floats for delivery but one bicycle and one motor cycle were employed in addition, the other retailer used a motor van. There are considerable differences with regard to the amount and nature of the equipment present on the holdings and consequently there is no close association between the value of equipment and the quantity of milk handled. In some cases farmers had boilers and sterilising plant whereas in others only the bare necessaries, such as churns, buckets and measures were found. When the farmers using floats are taken alone the total investment per farm in equipment and vehicles is £56, 29 per cent. in the former and 71 per cent. in the latter, and this amounts to £4 7s. 2d. per gallon.

All the milk going off these seven farms was sold retail. For the whole group 38 per cent. was sold in bottles and the remainder from churns. One producer did no bottling but five cases return more than 50 per cent. of their supplies sold " loose."

TABLE II.

Capital Investment. (Seven Farms).

	Total.	*Per Farm.*	*Per Daily Gallon.*	*Per Cent.*
	£ s. d.	£ s. d.	£ s. d.	
Equipment	114 0 0	16 5 8	1 5 1	27.2
Vehicles	305 0 0	43 11 5	3 7 0	72.8
Total	419 0 0	59 17 1	4 12 1	100.0

Beginning at the farm and completing the round, it is found that the distance travelled per day ranged between eight and twenty miles, with an average of 17.4 per farm; this is equal to 1.8 miles per gallon of milk sold.

The labour engaged on the work of delivery was as follows: In three cases one man was considered sufficient to dispose of the farm's supply, in two other cases two adults were employed, whilst the remaining two rounds had one man and one boy on each. On the average the manual labour time spent in travelling and the disposal of the milk was eight hours per round and sales were being made at the rate of 1.6 gallons an hour, or expressed in another way, it took just over thirty-seven minutes to dispose of one gallon of milk.

TABLE III.

Cost of Distribution per Day.

	Group.	*Per Farm.*	*Per Gallon.*	*Per Cent.*
	£ s. d.	s. d.	d.	
Upkeep of Equipment	0 2 2	0 8	0.8	4.4
Upkeep of Vehicles	0 18 1	1 10	1.8	26.6
Labour	1 13 11	4 10	4.4	69.0
Total	2 9 2	6 11	6.5	100.0

The cost of delivery will depend to some extent upon the number of times customers are visited. The unit found to be selling the smallest quantity per hour, viz., 0.9 gallons and taking

the longest time to sell one gallon, viz., 1.1 hours, reports calling upon all customers three times a day whilst the fastest seller, at 2.7 gallons per hour, only makes one call a day. Five roundsmen make only one call, one makes two whilst the remainder make three. In recent years it seems that customers have been making increasing demands upon retailers in this respect, many expect an early morning visit, with another before mid-day, and in a large number of cases an additional visit has to be made for the purpose of picking up empty bottles.

Retail Rounds between 20 *and* 29 *Gallons.*

For the thirteen businesses included in this group the average sales from the farms amount to 22.6 gallons per day with a range between 20 and 28 gallons. Floats were used for delivery by eight farmers and on the other five holdings vans were used, in addition three bicycles were used to assist in the work of delivery by the retailers who used floats.

TABLE IV.

Capital Investment. (Thirteen Farms).

	Group.	*Per Farm.*	*Per Daily Gallon.*	*Per cent.*
	£ s. d.	£ s. d.	£ s. d.	
Equipment	301 10 0	23 3 10	1 0 6	23.2
Vehicles	998 0 0	76 15 4	3 7 10	76.8
Total	1,299 10 0	99 19 2	4 8 4	100.0

The presence of vans on so many farms tends to increase the investment on these holdings relative to the preceding group. When the five farms using vans are taken separately it is found that the total investment per gallon is £4 15s. 11d. as against £8 18s. 1d. for those using floats. In spite of the fact that investment per holding is comparatively heavier in the case of the larger sized businesses, there appears a fall per gallon of milk handled, although several of these producers, especially those using vans, had equipped their dairies with comparatively up-to-date utensils.

The retail trade absorbed 97.8 per cent. of the total milk leaving these farms, and the small remainder went through wholesale channels. Taking only the milk sold retail, 40 per cent. was bottled and 60 per cent. " loose "; all producers bottled a part of their supplies, seven cases report selling 50 per cent. or more of their total in bottles.

Again including the run from the farm to the city, the average travelling distance on the complete round was 25.2 miles or 1.1 miles per gallon of milk sold; this latter figure is slightly lower than for the group of smaller businesses. The distance covered to dispose of a gallon was 1.8 miles for vans and 0.9 miles for floats.

TABLE V.

Cost of Distribution per Day.

	Group.	*Per Farm.*	*Per Gallon.*	*Per cent.*
	£ s. d.	*s. d.*	*d.*	
Upkeep of Equipment	0 8 5	0 8	0.3	6.9
Upkeep of Vehicles	1 18 1	2 11	1.6	31.1
Labour	3 15 8	5 9	3.1	62.0
Total	6 2 2	9 4	5.0	100.0

In six cases only one man was employed for each round, two adults were, however, engaged in two cases, in four more one adult and one juvenile, and on the remaining round two adults and one boy. The average manual labour time spent on each round was 7.8 hours per day; the average number of gallons sold per hour was 2.3; this is again a considerable improvement on the group above where it only amounted to 1.6 gallons. The average time taken to sell a gallon is also lower at 26 minutes. On this group of farms there is no significant difference between floats and vans in time required.

Great variation is again shown with regard to the number of calls made by the roundsmen on customers; seven cases report calling once, but the remainder call twice or in some cases three times.

Retail Rounds between 30 and 39 Gallons.

In this group there are twelve businesses, the gallonage handled ranging between thirty and thirty-eight with an average figure of 33.2 per farm. Floats were used by seven farmers but in five of these cases bicycles were employed in addition, four farmers had vans whilst the other had both a van and a float in operation. With the increase in the quantity of milk dealt with it is to be expected that heavier investments will be found, the figure is again lower, however, when considered per gallon. For the farms using floats the average investment per gallon is £2 10s. 0d. and for those having vans £4 12s. 0d.

Eight of the farmers in this group sold some milk wholesale and on the average 28 per cent. of the total leaving the farms was disposed of in this way. All producers sold some bottled milk but of the total amount going in the retail market 48 per cent.

TABLE VI.

Capital Investment. (Twelve Farms).

	Group.	*Per Farm.*	*Per Daily Gallon.*	*Per cent.*
	£ s. d.	£ s. d.	£ s. d.	
Equipment	388 14 0	32 7 0	0 19 5	30.3
Vehicles	892 10 0	74 7 6	2 4 9	69.7
Total	1.281 4 0	106 14 6	3 4 2	100.0

was sold "loose" and 57 per cent. bottled; nine of the farmers disposed of over 50 per cent. of their retail supplies in bottles.

The average distance travelled on rounds each day was 20.1 miles; or, 0.6 miles per gallon sold; for vans the figure was 0.8 miles and 0.4 miles for floats.

In only three cases was one man considered sufficient to deal with the supply of a farm; seven cases report one man and one boy on the work, whilst the two remaining employed two men and one boy on both rounds. The average time taken to deal with the supply of a business was 10.3 hours; the number of gallons sold per hour, however, is higher at 3.2 whilst the time taken to sell a gallon only amounts to about nineteen minutes in this group.

Motor vans show greater efficiency than floats for these comparatively large businesses; when relatively long distances have to be covered much valuable time may be saved by the use of vehicles that can travel quickly and customers can be reached at an earlier hour. The gallons sold per hour in the case of vans amounted to 4.3 although on the average they cover twenty-eight miles a day in the work of milk delivery. Floats on the other hand only cover fifteen miles, yet only 3.3 gallons are sold per hour. Five of the twelve suppliers called on customers once only, but six made two visits each day whilst the other made three.

Floats again show lower costs at 3.2d. per gallon, whereas vans alone stand at 3.8d. When groups are compared the fall in delivery cost with an increase in the milk handled becomes quite significant.

TABLE VII.

Cost of Distribution per Day.

	Group.	Per Farm.	Per Gallon.	Per cent.
	£ s. d.	s. d.	d.	
Upkeep of Equipment	0 9 11	0 10	0.3	7.8
Upkeep of Vehicles	2 7 3	3 11	1.4	37.1
Labour	3 10 3	5 10	2.1	55.1
Total	6 7 5	10 7	3.8	100.0

Retail Rounds over 39 Gallons.

Nine producer-retailers are included here, some of these handle large quantities of milk but the average daily sale off farms is fifty-eight gallons. Only two farmers used floats, the other seven had vans, but both a float and a van was used by one farmer.

TABLE VIII.

Capital Investment. (Nine Farms).

	Group.	Per Farm.	Per Gallon.	Per cent.
	£ s. d.	£ s. d.	£ s. d.	
Equipment	361 10 0	40 3 4	0 18 9	23.7
Vehicles	1,165 0 0	129 9 0	2 4 2	76.3
Total	1,526 10 0	169 12 4	2 17 11	100.0

Although investment per farm is heavier in this group, for each gallon of milk sold there is again an appreciable drop compared with the smaller businesses in spite of the fact that on most of these farms more efficient equipment was found than on several of the smaller ones. These farmers were genuinely engaged in the retail business; 85 per cent. of the milk leaving the holdings was sold directly to consumers, whilst that disposed of wholesale was usually only small quantities that were surplus to the day's requirements. Seventy-seven per cent. of the retail sales was bottled and all farms returned more than 50 per cent. sold in that way, whilst some offered no loose milk to customers.

The average daily travelling distance for the disposal of a farm's supply was thirty-six miles; this amounted to 0.6 miles per gallon of milk sold, which is a similar result to that obtained for the group selling up to 39 gallons per day.

On only one farm was the work of delivery done by one man; in three cases two adults were employed, another

returns four adults at work; on two other rounds two men and two boys each were employed, whilst in the disposal of the milk of the remaining farm three adults and three boys were found to be necessary, but some ninety gallons a day were handled in this latter case.

The time required on the average to dispose of the milk of a farm was 18.3 hours; whilst the hourly sale was 3.2 gallons; this is again similar to the group above, and the time taken to sell a gallon was the same, viz., about nineteen minutes.

TABLE IX.

Cost of Distribution per Day.

	Group.	*Per Farm.*	*Per Gallon.*	*Per cent.*
	£ s. d.	s. d.	d.	
Upkeep of Equipment	0 11 9	1 4	0.3	8.0
Upkeep of Vehicles	3 1 1	6 9	1.3	34.3
Labour	4 17 1	10 9	2.2	57.7
Total	8 9 11	18 10	3.8	100.0

The greatest disturbing factor in the situation is again the number of visits paid each day to the same customers. Four of these nine producer-retailers delivered only once, two visited some houses twice but the other three called twice on all customers.

Comparison by size of round.

In order to epitomise the foregoing analysis Table X has been prepared; this shows the essential differences in the economy of the retail business when rounds of different sizes are compared.

TABLE X.

Capital Investment. (All Farms).

Size of Business.	*Average Quantity handled*	*Investment in Equipment.*	*Per cent of Total*	*Investment in Vehicles*	*Per cent of Total*	*Total Investment*
Gallons per Day.	*Gallons per day.*	*Per Gallon.* £ s. d.	%	*Per Gallons.* £ s. d.	%	*Per Gallon.* £ s. d.
10—19	18.0	1 5 1	27.2	3 7 0	72.8	4 12 1
20—29 ...	22.6	1 0 6	23.2	3 7 10	76.8	4 8 4
30—39	33.3	0 19 5	30.3	2 4 9	69.7	3 4 2
Over 39	58.0	0 13 9	23.7	2 4 2	76.3	2 17 11
Mean	27.6	0 17 9	25.7	2 11 3	74.3	3 9 0

With the increase in the size of the businesses there is a persistent tendency for investment per gallon to fall; in all groups about a fourth of the total is in equipment and three-fourths in vehicles. It is clear that although the capital necessary increases as more milk is handled the rise is far less than proportional and a significant economy is obviously effected when, as appears from the figures, the total investment per gallon falls by 87 per cent. with an increase in the quantity handled from thirteen to fifty-eight gallons. On many of the larger holdings the equipment was far more elaborate, costly and modern than on the smaller holdings whilst it was on the bigger farms that vans were principally found.

Vans versus Floats.

The farmers using vans can in general be considered the more progressive type as their holdings had been set out for the production and subsequent handling of milk in a comparatively satisfactory way. It is to be expected that investment in vehicles will be higher on holdings using vans but as the figures show, the investment in equipment is also considerably in excess of that found upon farms using floats. The difference per gallon between these two classes of holdings is not so conspicuous, however, as more milk was usually handled in the business which used vans for disposal.

TABLE XI.

Capital Investment per Farm and per Gallon.

	Farms using Floats.		*Farms using Vans.*		*All Farms.*	
	Per Farm.	*Per Gallon.*	*Per Farm.*	*Per Gallon.*	*Per Farm.*	*Per Gallon.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Equipment	22 18 0	0 17 6	38 10 7	1 1 5	28 7 6	0 17 9
Vehicles	51 13 1	1 19 11	118 7 1	3 5 10	82 0 1	2 11 4
Total	74 6 1	2 17 5	156 17 8	4 7 3	110 7 7	3 9 1

One of the factors that should be borne in mind when the use of vans or floats is under consideration can be seen in Table XII; which also shows the influence of size of the business upon the distance travelled in the disposal of a gallon of milk.

TABLE XII.
Travelling Distances.

Size of Business.	*Distance travelled per gallon sold.*		
	Floats.	*Vans.*	*All Farms**
Gallons per Day.	*Miles.*	*Miles.*	*Miles.*
10—19	1.3	1.5	1.2
20—29	0.9	1.3	1.1
30—39	0.4	0.9	0.6
Over 39 .., ...	0.3	0.8	0.5
Mean	0.6	0.9	0.7

* In this column several additional farms are included, *i.e.*, those where various other methods of delivering milk are adopted such as bicycles and motor cycles to aid the floats, a few of the farms included, however, use only motor cycles. The cycles and motor cycles tend to have a shorter range than either horse vehicles or motor vans.

For all groups floats cover shorter distances than vans in the disposal of the milk; the possibility of rapid transit by means of motor vehicles enables operators to cover large and highly scattered rounds. Roundsmen find that it is necessary to supply customers by a certain time each day and a fair amount of regularity must be observed. Consequently floats can only operate successfully in a more or less compact and limited area. Moreover, considerable economies are achieved by the farmers operating on the larger rounds; in the case of those using floats, the fall in average distance covered in the disposal of a gallon is almost proportionate to the increase in the quantity handled when the smallest group is compared with the largest. Although the tendency is in the same direction for rounds on which vans are used the actual fall in the distance covered is not as great.

The time taken to deliver milk to customers is a very important factor in total costs; of course the time taken to travel from the farm to the city is in some cases rather significant, especially when floats are used and where the distance is rather great. Vans, however, would be faster not only in getting to the city but, on the whole, would be quicker in passing from one customer to another.

When the group using floats is compared with the one using vans there is not much difference on the whole in the time expended in the delivery of one gallon. Vans may be quicker but in general they cover greater distances in the course of their daily work. It is clear, however, that the larger businesses are able

to do the work in much shorter time per unit of quantity handled; this is especially the case where floats are employed, and in general it is true also of those businesses using vans.

TABLE XIII.

Gallons sold per hour and Labour Hours taken to sell one Gallon.

Size of Business. Gallons per Day.	Floats.		Vans.		All Farms.	
	Gallons per Hour.	Minutes per Gallon.	Gallons per Hour.	Minutes per Gallon.	Gallons per Hour.	Minutes per Gallon.
10—19	1.6	36	1.5	42	1.6	36
20—29	2.8	24	2.2	30	2.3	24
30—39	3.3	18	4.3	12	3.2	24
Over 39	5.8	12	2.7	18	3.2	18
Mean	2.9	24	2.8	24	2.7	24

There is, however, one factor of some unmeasured importance in the differences shown in the final columns of Table XIV. It is shown in another study[2] that average daily intake of fresh milk per household varies in different areas of the City and with different classes of consumers. On the whole the bigger businesses, and those using the more up-to-date equipment, and in some cases, particularly those using vans, are able to establish rounds in the areas in which the higher intakes per household occur. But on any given round deliveries may be made to some households which take an average of a quart or more per day, and to other households which take an average of only one pint per day. As it was not possible to obtain for each round the total or daily average number of customers it was not possible to get a measure of this factor.

Delivery by floats on the whole is the cheaper method; although vans may do a certain amount of work in shorter time, this factor is not sufficient to offset the higher costs involved in running them. It must, however, be borne in mind that in the area investigated these two kinds of vehicles are not operating over exactly the same routes and that they do not cover the same distances. It would be necessary to test them under exactly the same circumstances to find the real differences in cost. The figures are sufficiently illuminating to indicate the actual conditions prevailing in the City of Cardiff. Some vans are, it is

[2] This *Journal*, p. 88.

true, able to bring milk into the City from greater distances than would be practical if floats were used, such milk may be produced on farms where rents are comparatively lower than in the immediate vicinity of Cardiff and this may offset the higher cost that the farmers have to bear in sending their milk by vans

TABLE XIV.

Daily Delivery Costs per Farm and per Gallon.

	Farms using Floats.		*Farms using Vans.*		*All Farms.*	
	Per Farm.	*Per Gallon.*	*Per Farm.*	*Per Gallon.*	*Per Farm.*	*Per Gallon.*
	s. d.	*d.*	*s. d.*	*d.*	*s. d.*	*d.*
Upkeep of Equipment	0 8	0.3	0 11½	0.3	0 9½	0.3
Upkeep of Vehicles	1 11½	0.9	6 10	2.0	3 10½	1.5
Labour	5 3	2.5	7 5	2.5	6 9½	2.5
Total	7 10½	3.7	15 2½	4.8	11 5½	4.3

some considerable dstances. The incidence of the various items entering into costs can be seen from Table XIV. The cost of vehicles is a very significant item in the total cost per gallon. There is no appreciable difference between the two groups of farms with regard to equipment and labour. The heavier cost on the farms using vans is almost entirely due to the relatively heavy cost of vehicle upkeep.

Manual Labour Costs.

In view of the importance of manual labour in delivery costs it is interesting to compare the figures in Table XIII with those given below in Table XV.

TABLE XV.

Labour Cost of Distribution per Gallon.

Size of Business.	*Floats.*	*Vans.*	*All Farms.*
Gallons per day.	*d.*	*d.*	*d.*
10—19	4.4	4.8	4.4
20—29	3.1	3.1	3.1
30—39	2.0	1.6	1.9
Over 39	1.3	2.5	2.2
Mean	2.5	2.5	2.5

The question of labour cost is one of the most difficult to treat in an investigation of this character. Some few workers, namely those who are wholly or almost wholly employed in retail distribution and "milk work,"[3] are legally entitled to the rates of wages determined by the Milk Distributive Trade Board. These rates, applicable to workers fully employed in retailing, etc., in the City of Cardiff, are those for "Area B" under the current Order; and they vary between 12s. 0d. per week for boys under 15 or from 14s. 6d. for boys of 15 years to 52s. per week at 21 years and over. The 22s. 6d. per week allowed in this investigation for juvenile labour lies between the Trade Board rates for workers of sixteen and seventeen years of age, but this rate applies to agricultural rather than to milk trade workers. Those workers who are not wholly or almost wholly employed in milk work are not entitled to the rates fixed by the Trade Board, but are entitled to the current rates paid for workers in agriculture. The *average* estimated cost of labour of boys, women, and men over all the farms is just over 7d. per hour, but it varies a little from one group to another according to the proportions of youths and adults engaged. If the rate is raised to 10½d. per hour, the average cost of manual labour per gallon delivered will be 8¾d., and the average total cost of delivery including labour and other charges will be raised by 1¼d. per gallon.

Interest Charges.

No interest has been allowed in the statement of costs, but most producer-retailers would insert a charge for interest on capital. The tendency is to assess interest charges at somewhat excessive rates, especially after full allowance has been made for depreciation and upkeep. Full allowances for these items have been made in these cases. Adding interest at 5 per cent. per annum on the full value of horses and vehicles and utensils, etc., used in retailing, the cost per daily gallon of milk delivered would be :—

	Interest.	*Cost without Interest.*	*Total Estimated Cost.*
	d.	*d.*	*d.*
Group 1. 10—19 Gals.	0.15	6.50	6.65
,, 2. 20—29 ,,	0.14	5.00	5.14
,, 3. 30—39 ,,	0.10	3.80	3.90
,, 4. Over 39 ,,	0.10	3.80	3.90
All Farms	0.11	4.30	4.41

[3] See F. 426. Explanatory Memorandum Trade Board (Milk Distributive) Order.

The Quality of the Milk.

Little progress has been made in the area towards producing milk with a specific form of guarantee of high quality, or which would be eligible for sale under the terms of the Milk (Special Designations) Order, 1923. As was mentioned previously, however, some of the producer-retailers consulted had not set out in the business with a view to adhering to it and building up an established trade on a more or less permanent basis. The majority had turned to it from other systems of farming and a few had only taken it up temporarily. As a result of this comparatively unsatisfactory state of affairs it is not surprising to find that of the total milk delivered to consumers by the producer-retailers only 8 per cent. was of " Grade A " standard. No " Certified " or " Grade A. T.T. " milk was produced on any of the farms investigated. From another investigation into the milk supply of Cardiff it was found that city retailers supply 5 per cent. in the form of graded milks.

Only two of the farms visited had suitable buildings and the necessary facilities, in the form of a supply of water laid on, and with adequate drainage conveniences, for the production of milk of the official standard Grades. Capital will have to be laid out on improvements to buildings, more plentiful supplies of water will be required on many farms before they can be considered as hygienic dairies. Methods of illumination were hopelessly inadequate on many holdings, but the spread of supply of electricity in the district may serve to ameliorate conditions in this respect if its advantages are brought to the notice of farmers.

It is often mentioned that the demand for milk is inelastic; meaning that the amount taken by consumers changes but little as a result of changes in price. Many of the producer-retailers expressed doubt regarding the truth of this assertion; several claimed that the price factor was of supreme importance in milk selling. Quite naturally producer-retailers are apt to be confused on this point, and fail to make the distinction between increase in the total demand for milk and the demand for the supplies they offer at the prices they fix. With a fall in the price of one retailers' supply his business may increase, but partly at the expense of other rounds. At the same time, the general judgment of producer-retailers was that price is an important factor in the determination of the total demand.

Farmers certainly find consumers to be very responsive to price in building up rounds. Several had experienced but little

difficulty in establishing or extending rounds by cutting the price by 1d. a quart. Many housewives will change their suppliers easily, quickly and without notice, if milk can be obtained from another source at a lower figure. Some of the producer-retailers who had held well established rounds for years expressed grave fear of losing them to undercutters and in fact a large part of the business of retailing appeared to be in a perpetual state of transition.

There is an increasing desire amongst customers for milk to be supplied in bottles. It is far more convenient for both the roundsman and the housewife, and expedites to some extent the work of distribution, as a wait at the doorway is usually avoided. There do not seem to be many requests for graded milks, but again the price factor comes into play as only a few consumers are prepared to recompense the producer for the higher costs involved.

It is becoming more difficult for producer-retailers to stand in competition with City retailers in view of some of the extremely exacting services demanded by many customers. In general, especially in the smaller businesses, farmers must return to their holding soon after mid-day in order to attend to the work of production. Few producer-retailers employ special men for the work of distribution, usually they perform other tasks in the course of the day. Nevertheless, 50 per cent. of the producer-retailers attempted to call upon the same customers more than once in the same day and generally succeeded, 12 per cent. visited all houses twice daily regularly. It appears, however, that only 35 per cent. of the City retailers confine their calls to one a day. Producer-retailers have in many cases entered upon the work without an adequate knowledge of its various aspects; several have merely blundered along and have only been able to hold their own by undercutting the price. It is to be hoped that agricultural prices generally will improve so that many now attempting to dispose of their milk directly to consumers will return to other systems of farming for which they have been trained and in which they have had more experience.

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THE CONSUMPTION OF MILK IN CARDIFF.

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Very few studies of milk consumption have been made in this country and but little reliable information is available on the subject. Rough calculations of quantities consumed per head of the population have been made, but the results are obtained merely by dividing the estimated total quantities consumed per head of the population by the number of persons in the country; the results so obtained, however, are of very limited value. The Local Food Committees collected some data in 1918 and estimated that at that time the consumption of milk in Great Britain was 0.25 of a pint per day,[1] but, as conditions were then abnormal it does not follow that this figure is correct for later years. The Ministry of Agriculture and Fisheries estimated that the total milk consumed in Great Britain during 1921 was 600 million gallons; this represented a *per capita* consumption of 0.31 of a pint per day, and in 1922 it was estimated at between 650 and 700 million gallons, which represented between 0.33 and 0.36 of a pint a day per person.[2] Another investigation into the consumption of milk in a number of towns and cities shows that on the average it is just under 0.38 of a pint per day, the predominant range being between 0.25 and 0.40 of a pint.[3] Other enquiries yield results of a somewhat similar nature; one gives a daily figure of 0.28 of a pint,[4] another places consumption at 0.44 of a pint per person.[5] From the investigations that have been made

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1 Final Report of the Committee on the Production and Distribution of Milk, 1919 (Cmd. 483).

2 Linlithgow Committee: Interim Report on Milk and Milk Products (Cmd. 1854).

3 The Fluid Milk Market in England and Wales. Ministry of Agriculture Report. Economic Series No. 16.

4 United Dairies, Ltd., Annual Report (1928).

5 The Agricultural Output of England and Wales, 1925 (Cmd. 2815), and the Agricultural Output for Scotland, 1925 (Cmd. 3191).

it appears that the daily consumption of milk per head of the population falls between three-tenths and two-fifths of a pint.

Rough calculations which are based upon the number of people likely to take milk and the estimate of supplies sold for consumption in liquid form do not provide adequate information for those engaged in the business of production and disposal of the supply. It is known that all persons or families do not take the same quantity, but knowledge of variations in consumption and the factors responsible for them is rather limited. It is assumed, for instance, that changes in the retail price of milk do not affect the quantity sold to consumers to any appreciable degree. Further, it is believed that the more prosperous classes in the community take all the milk that they can use to advantage, and from this it is inferred that they would not increase their purchases if supplies were offered to them at a lower rate, but with regard to the poorer classes, it is sometimes maintained that a drop in the retail price of milk in the areas in which they live would result in greater sales. It is apparent, however, that the consumption of milk is influenced by many factors, some of which may be rather obscure and difficult to isolate. Moreover, the quantity of fresh milk taken by a family may be closely associated with the consumption of other foods of a milk origin which they use as substitues. In this study, therefore, an attempt is made to throw some light upon the forces which have some influence upon the quantity of milk consumed.

PART I.

Consumption in Cardiff.

An investigation was made in Cardiff during 1933 in co-operation with the Public Health Department of the City. Four districts were selected according to the general standards and conditions of living of the inhabitants. The districts can be described as follows :—

I. Good Middle Class.
II. Good Working Class.
III. New Housing Area.
IV. Poor Working Class.

These descriptions apply to the general characteristics of the districts rather than to the people themselves. Without a meticulous examination of incomes it is almost impossible to define the economic standing of families within any one area or of any group. The terms used are those of common parlance, and their significance should be generally understood without further

definition. A " new housing " area was included at the express suggestion of retail dairymen in the City.

An attempt was made to get accurate details regarding the milk used from the people living in the four districts. In view of the interdependence between the quantity of milk taken in a household and the purchases of other somewhat similar foods, information relating to milk alone would be inadequate, as it is to be expected that the prices of substitutes are likely to affect the consumption of fresh milk. The data was collected by the use of a circular which was sent to a large number of households in each district, and questions were asked on all matters that might bear upon the problem under consideration. A sufficient number of replies was received from the areas, so that each sample is known to be representative of the district from which it was taken, whilst it can be shown that the conditions obtaining in these districts are accurately reflected in the results submitted in this study.

The census was taken during the week ending April 8th, 1938. This period was selected with the object of excluding some factors which influence the milk trade. It is known that the consumption of liquid milk is greater during some months of the year than others, partly as a result of climatic and weather conditions. Moreover, holiday seasons affect the sales of milk to an appreciable degree; in August sales in the City show a considerable decline as a result of the outward movements of population. April is not the period of highest sales—these would come later in the summer—but they may be slightly heavier at this time than during some other months. The consumption of milk powder and special milk preparations is most probably somewhat lower than would be shown by a record for the winter. Consumption of several forms of milk is not necessarily a matter of regular habit, and there are variations at different times of the year and under certain circumstances. Some of these, such as a cold period or an epidemic of colds or of influenza, would increase the consumption of preparations of milk powder. Such special conditions were absent during the week that the recording was done. Consumption during the week chosen, therefore, can be considered as representative of that season of the year.

Prices of liquid milk during the time were not stable, as an appreciable amount of undercutting was common. Some retailers were offering at 4d. a quart; others at 5d. The nominal established price was 6d. a quart in most districts, but the average price was approximately 5¼d. per quart.

When the four classes of consumers are considered separately as in Table I, there appears a wide variation in the quantities consumed.

TABLE I.

Consumption of liquid (fresh) milk per week.

Groups.	*Liquid Milk per Person.*	*Liquid Milk per Family.*	*Average size of family.*	*Total Milk per person in houses taking liquid milk.*	*% houses taking liquid milk.*
	Pints.	*Pints.*	*Persons.*	*Pints.*	%
1. G.M.C.	3.88	15.21	3.92	3.88	100
2. G.W.C.	1.87	7.47	3.99	2.05	91
3. N.H.A.	1.32	6.38	4.78	1.53	85
4. P.W.C.	1.10	4.31	3.93	1.45	74
Mean	2.00	8.34	4.16	2.27	87

Between the most and the least prosperous groups there is no significant difference in the average size of the family, yet the quantity of milk taken per house over all the households is more than three times greater in the best district. It is clear also that as households are grouped more or less by their estimated incomes, there is a definite and persistent decline in the quantity of fresh milk going into the homes as one passes from the better to the poorer classes. When the daily figures are examined it is found that over the whole the result agrees quite well at 0.29 of a pint per day with the estimates quoted above.[6] When, however, the four groups of consumers are considered on a daily basis, the average quantities taken *per capita* over all the persons in the households are as follows :—

			Pints per head per day.
I.	G.M.C.	....	0.55
II.	G.W.C.	....	0.27
III.	N.H.A.	....	0.19
IV.	P.W.C.	....	0.16
Average		....	0.29

It is not to be assumed that all the milk passing into the houses is consumed by human beings, part of it may be given to animals or used in other ways, but this aspect of the matter has no great relevance to the present study. From the retailers' and

[6] The agreement, however, is closer when the daily consumption per head in households purchasing fresh milk is considered—namely, 0.324 pints.

producers' viewpoint it is important to know how much customers are prepared to take at given retail prices. From the public health point of view, however, it may be necessary to make some allowance for non-human consumption. No investigation was made of this factor. Most probably it may be assumed that more milk is fed to cats and dogs at the higher income levels; but, more particularly, that more milk is fed to animals where there are few or no children. Still, it must not be assumed that no milk is fed to animals in any of the groups, even in that with the lowest general conditions of life.

When the money value of the milk sold into the houses is considered, there appears a wider variation between the groups than when physical quantities are given. This is partly due to

TABLE II.
Quality and Cost per week of Liquid Fresh Milk.

Groups.	*Cost per Person.*	*Cost per Family.*	*Cost per person in houses taking liquid Milk.*	*Percentage as—*		
				*Special.**	*Bottled.*	*Loose*
	d.	*d.*	*d.*			
I. G.M.C.	10.85	42.54	10.85	7.7.	74.8	17.5
II. G.W.C.	4.90	19.25	5.30	0.5	60.5	39.0
III. N.H.A.	3.44	16.61	4.00	9.9	50.6	39.5
IV. P.W.C.	2.75	11.00	3.66	7.2	36.9	55.9
Mean	5.25	22.40	6.10	6.3	55.7	38.0

* Special includes—" Certified," " Grade A (T.T.) " and " Grade A."

differences in the nature of the supplies bought, although the more prosperous people do not buy a larger proportion of graded milk, a higher percentage of their total deliveries is bottled. The comparatively small quantity of special grade milk supplied on the whole is conspicuous, and while there appears to be some movement towards its more extensive use, many difficulties have still to be overcome. Many people lack a correct knowledge of the various designations of quality, whilst but few understand their meaning. Attention is often drawn to the comparatively high production costs of graded milk, but this is not the only factor that tends to enhance the price of this class of milk. At present the houses requiring graded milk are often widely scattered and interspersed amongst consumers of ungraded milk. Roundsmen supplying milk of special quality have, therefore, to travel enormous distances each day before completing the work

of delivery. This additional cost of distribution is often overlooked, although it is extremely important and must be met. Further, roundsmen often find it impossible to call on all the widely dispersed customers at a sufficiently early hour to keep them satisfied with the service that is rendered. When graded milks are carried with ordinary commercial milk there is extra trouble, cost, and sometimes risk.

Condensed milk can be regarded as the most important substitute for fresh milk, and in general it is competitive. Tinned milk is sold both as "full cream" and as "skimmed," the latter being, of course, available at a lower price, but the relative cheapness of the two kinds is a debatable point, as quality must be taken into consideration. Cream may also be used instead of milk. Milk powder in a prepared form may be used as a baby food in some homes, whilst malted milk may be taken as a beverage, and either of these may displace liquid milk to a certain extent.

TABLE III.

Condensed Milks: Quantities taken and Cost per week of Tinned Milk.

Groups.	*Whole **				*% of Houses Supplied*
	(1) *Per House.*		(2) *Per Person.*		
	Pints.	*Cost.* *d.*	*Pints.*	*Cost.* *d.*	
I. G.M.C.	0.22	0.75	0.06	0.19	10
II. G.W.C.	0.20	0.68	0.05	0.17	7
III. N.H.A.	0.15	0.58	0.03	0.12	6
IV. P.W.C.	0.40	2.00	0.10	0.58	11
Mean	0.24	1.02	0.06	0.25	8

Groups.	*Skim †*				*% of Houses Supplied*
	(1) *Per House.*		(2) *Per Person.*		
	Pints.	*Cost.* *d.*	*Pints.*	*Cost.* *d.*	
I. G.M.C.	0.25	0.57	0.05	0.15	6
II. G.W.C.	1.94	4.00	0.39	1.00	54
III. N.H.A.	3.04	6.17	0.51	1.30	70
IV. P.W.C.	3.24	6.50	0.66	1.66	80
Mean	2.11	4.28	0.51	1.08	50

* The average cost per tin of full cream milk = 7d.; this is equivalent to about 1¼ pints of whole milk.

† The average cost per tin of skim milk = 2½d.; this is equivalent to about 1¼ pints of skim milk.

(1) All houses in the group are included.

(2) All persons in the group are included.

It is clear from the figures that, on the whole, comparatively small quantities of the full cream variety are bought, whereas considerable purchases of condensed skim milk are made, and further, it is the poorer classes that are the heaviest consumers of this commodity. The quantity of cream bought is relatively small; in the most prosperous district 36 per cent. of the houses report buying some; over the whole it only amounted to 1.6 oz. per house weekly. Only 2 per cent of the households, however, bought the proprietory milk foods. In the good working class district 7 per cent. of the families purchased cream, which yielded 0.2 oz. each per week, and not one returned purchases of baby food. In the new housing area and the poor working class district the percentages are 9 and 5, and the respective quantities 0.16 oz. and 0.12 oz. per family weekly.[7] When the average amount of money spent on these two classes of commodities, namely, cream and proprietory milk foods, is calculated, it is not surprising to find it comparatively small. The respective group figures for a week's supply are as follows :—

		d.
Group I	=	4.9
Group II	=	0.5
Group III	=	1.0
Group IV	=	0.6

It is impossible to reduce all the various classes of milk foods to a common basis except in terms of money value. Neither cream, skim-milk, nor the proprietory foods can be satisfactorily measured as food equivalents of liquid milk. The actual cost, therefore, of all classes of milk and milk foods per house and person comprising the households is given below. None of the families have been omitted in the calculation of this average, on the ground that they do not take all the different kinds of milk. Houses not taking liquid milk are studied separately, and some further analysis of such consumers' purchases is given.

When total consumption of milk in these forms is considered, the absence of any difference between Groups III and IV, and the absence of any real difference between these and Group II on the basis of expenditure per person is very remarkable. The expenditure of twice as much per head and per household in the best group as in any of the others is also remarkable. The question immediately arises whether this higher consumption is the result of higher purchasing power alone or fundamentally of different habits, or, as it might be expressed, of better dietetie

[7] A more complete analysis of cream purchases is given on p. 98.

education? Would an increase in purchasing power in other groups itself lead their households to increase up to the level of the best group? Would increase in purchasing power in the lower groups lead all their families to use fresh milk and to drop the use of condensed, whole or skimmed, especially the latter?

TABLE IV.

Total Expenditure on all Milk and Milk Foods per week.

Groups.	*Liquid (Fresh) Milk.*	*Condensed Milk.*	*Cream and Dried Milk.*	*Total per House.*	*Total Per Person.*
	Cost. *d.*	*Cost.* *d.*	*Cost.* *d.*	*s. d.*	*d.*
I. G.M.C.	42.54	1.82	4.9	4 0.75	12.44
II. G.W.C.	19.25	4.68	0.5	2 0.48	6.18
III. N.H.A.	16.61	6.75	1.0	2 0.36	5.01
IV. P.W.C.	11.00	8.50	0.6	1 8.10	5.12
Mean	22.40	5.80	1.8	2 5.50	7.07

No entirely adequate answer to these questions can be given. Many answers will doubtless be offered according to different personal readings of " human nature " or conceptions of the nature and formation of human habits. While it is suggested that no final answers are now possible, there is no desire to shirk responsibility for some judgments.

Although all the households in the middle class district obtained supplies of fresh milk, in all the other three areas a certain proportion of the population were not consumers of fresh milk; in the poorest district only three-quarters of the families bought the commodity. Information from retailers indicates that there are many people in the poorer areas of the city who form the opinion that they cannot afford fresh milk. It is true that the retail price of milk, during the years following the war, has been consistently above that of most other foods, and this may have limited consumption to a certain extent, especially in regions where standards of living are low. People whose incomes are limited purchase considerably less milk than their more wealthy neighbours. When it is realised that consumption amongst the poor only amounts to about a pint per person weekly, whereas it exceeds 8½ pints in the richer areas, it cannot be denied that income or purchasing power is rather an important factor, and it must influence demand to an appreciable degree. Further, it is almost certainly wrong to assume that the poor classes would not take considerably greater quantities of fresh

milk if they were financially able to do so, and there is no reason to believe that the consumption of milk in these regions could not approach that now attained in the more prosperous districts.

Some households rely entirely upon tinned milk, as they do not purchase any fresh milk; in the table below the purchases of consumers who fall into this category are presented.

TABLE V.

Consumption of Tinned Milk per week in houses not taking liquid milk.

Groups.	*No. of Houses.*	*Whole.* Per House. Pints.	*Whole.* Per House. Cost. d.	*Whole.* Per Person. Pints.	*Whole.* Per Person. Cost. d.
II. G.W.C.	9	—	—	—	—
III. N.H.A.	14	0.21	1.14	0.04	0.25
IV. P.W.C.	26	0.63	3.42	0.16	0.98
Mean	—	0.49	2.66	0.12	0.65

Groups.	*Skimmed.* Per House. Pints.	*Skimmed.* Per House. Cost. d.	*Skimmed.* Per Person. Pints.	*Skimmed.* Per Person. Cost. d.
II. G.W.C.	3.90	8.22	1.07	2.31
III. N.H.A.	5.02	10.14	1.11	2.18
IV. P.W.C.	5.10	10.15	1.38	2.75
Mean	4.54	9.80	1.15	2.49

In the good middle class group all the houses take liquid milk, consequently it is excluded from the above table. In the good working class area there are nine cases receiving no supplies of fresh milk; it appears, however, that some of these families were in financial difficulties at the time, and as a result temporary curtailments of expenditure had been made. These people, moreover, did not purchase any full cream tinned milk, but relied upon the skimmed variety. The need of supplies of fresh milk is obvious from a study of the constitution of some of the families. There were twelve children present in these nine homes, five of whom were under seven years of age. None of the houses purchased any other kind of milk food, whilst only one child received milk at school. The remaining eleven children, therefore, had to be content with condensed skim milk.

Taking another group of consumers, those living in the new housing area, it is found that 14 per cent. of the families do not

buy fresh milk. In these houses twenty-six children are being reared, sixteen of whom are under seven years. Full cream milk is bought by only one household, whilst two others buy small quantities of tinned cream, in one case it is 9d. worth a week, whilst the other only expends 3d. on this commodity in the same period Only two children are provided with milk at school, so it appears that there must be a requirement for milk in these homes but for some reason the requirement is not translated into effective demand.

The "poor working class" group here dealt with is not necessarily the poorest in the city for none commonly regarded as slum areas were included in the study. In this group there were twenty-six houses not taking liquid milk, these were inhabited by sixty-six adults, eighteen children between seven and fourteen years and thirteen younger ones. Four of the twenty-six families report buying full cream milk and none of these buys the skimmed variety. The quantity bought is equivalent to about 4½ pints per house weekly; no other kind of milk food is purchased. Not a single one of the remaining twenty-two households obtain any kind of milk food other than tinned skimmed whilst only four of the children living in these homes are supplied with milk at school. It is therefore apparent that twenty-four children, ten of whom are under seven years have to depend entirely upon tinned skim for their requirements of milk.

These figures are based upon a study of samples from each region, but as these are representative of the areas from which they have been obtained they portray conditions in the various parts of the city within comparatively narrow limits. In the group of poor working class families just over a quarter of the people do not consume fresh milk and 21 per cent. of the children between seven and fourteen years have to live without any supplies of fresh milk whilst 24 per cent. of those under seven years are brought up under the same unfortunate circumstances. It is obviously a most undesirable state of affairs when it appears that about one-fifth of the children in the poorer districts of Cardiff are deprived of the food that is so essential for their healthy development.

Among the other classes of citizens conditions are better, there does not appear to be any privation with regard to milk in the middle classes. But even amongst the good working class group this study shows that about 10 per cent. of the children are not given fresh milk at home. As this proportion is comparatively small it cannot be inferred that the custom of giving only

skimmed condensed milk to children is widespread or permanent. Persons conversant with the situation state that the prolonged period of unemployment has meant real privation in many homes not only with regard to milk but also in other equally important necessaries. A situation, however, where parents find it essential to limit the milk rations of their children must be damaging to health. In the new housing area conditions could also be improved, as the amount of milk taken is comparatively low whilst 11 per cent. of the children are dependent on skimmed condensed. It is obvious that many families are not in a position to feed their children adequately. Milk which is so essential to children should certainly be provided for them and the scheme for providing part of their requirements at school should be extended. Further, if the purchasing power of the poorer people cannot be increased in the near future to such an extent that they can at least afford to take some fresh milk, is it not possible to provide supplies at a lower price in those regions which are poverty stricken?

Cream: The consumption of cream varies enormously between the seasons of the year but in general there is a fairly steady demand for a certain small quantity especially amongst the more prosperous classes. During early April, however, there cannot be an appreciable increase in demand over the normal as this is too early for the effect of the soft fruit season to be felt. Except in the good working class district it is seen that only a very small proportion of the houses take cream, whilst in general the quantity taken is small. Cream is purchased either as fresh or tinned and it is of interest to note the respective proportions; the good middle class buy 90 per cent. of the total as fresh cream, the good working class 79 per cent., and in the new housing area it drops to 58 per cent., while in the poor working class homes only 30 per cent. is bought as fresh cream.

TABLE VI.

Consumption of Cream.

Groups.	*Per cent. of houses buying cream.*	*Total Quantity bought.*	*Total Cost.*	*Quantity per house.*	*Cost. per house.*
		lbs.	*s. d.*	*ozs.*	*d.*
I. G.M.C.	36	10.62	29 5	4.72	9.8
II. G.W.C.	6	1.37	4 0	3.67	8.0
III. N.H.A.	9	1.50	4 1½	2.67	5.5
IV. P.W.C.	5	0.75	2 4	2.40	5.2

Daily Fluctuations in Sales of liquid Milk.

Information obtained from several independent sources points to the fact that consumers do not require the same amounts of milk each day of the week. The following table indicates the fluctuations in demand throughout the week.

TABLE VII.
Liquid Milk taken per Household.

Groups.	*Sun.*	*Mon.*	*Tues*	*Wed.*	*Thurs.*	*Fri.*	*Sat.*	*Average per week.*
	Pints.	*Pints.*	*Pints.*	*Pints.*	*Pints.*	*Pints.*	*Pints.*	*Pints.*
I. G.M.C.	2.40	2.14	2.18	2.10	2.08	2.15	2.12	2.16
II. G.W.C.	1.57	0.96	1.04	1.00	0.97	0.94	0.99	1.07
III. N.H.A.	1.72	0.68	0.78	0.82	0.78	0.77	0.78	0.91
IV. P.W.C.	1.12	0.46	0.54	0.55	0.50	0.58	0.52	0.60
Mean	1.70	1.06	1.12	1.12	1.08	1.10	1.10	1.18

The above table indicates quite clearly some of the conditions of retailing milk as well as one of the features of consumption. If a retailer were delivering to all the hundred families in each of these groups, or delivering over the area covered by one hundred houses, his average daily delivery to each house would be as given in the last column of the Table. Not all households, except in Group I, however, purchase fresh milk. The average of total daily deliveries to households actually purchasing fresh milk are as follows :—

		Pints.
I. G.M.C.	....	2.16
II. G.W.C.	....	1.17
III. N.H.A.	....	1.07
IV. P.W.C.	....	0.81
All	....	1.36

The average daily delivery to even the best houses is only about one quart a day. In two other groups the average is about 1 pint per day, and 1½ pints on Sunday; and in the poorest group ¾ pints a day, or half a pint for six days and 1 pint on Sunday. And the area of one hundred houses has to be covered to average these quantities. For most of the houses in the best group, probably, there is more than one delivery—often more than one retailer; and some houses in the next two groups also get two deliveries.

In all groups the quantities taken on Sunday considerably exceed the average for the week. This is not so marked in the most prosperous district where the Sunday supply only exceeds the average for the week by 11 per cent., but in the good working class district the demand on that day is up by 47 per cent. In the region taking comparatively little milk the rise in week-end deliveries is enormous; the new housing area shows an increase of 90 per cent. and the poor working class district one of 86 per cent.

TABLE VIII.

Week-end Variation per House. Houses not taking Milk omitted.

Groups.	*Sunday.*	*Monday.*	*Average other Days.*
	Pints.	*Pints.*	*Pints.*
I. G.M.C.	2.40	2.14	2.11
II. G.W.C.	1.78	1.04	1.09
III. N.H.A.	2.02	0.80	0.92
IV. P.W.C.	1.51	0.62	0.71
Mean	1.95	1.21	1.26

The table gives the actual quantities taken on the average by the houses taking liquid milk. Houses relying on tinned milk are omitted and when this is done the difference between Sunday and Monday sales as distributors encounter it becomes apparent. As hardly any variation occurs in the quantities taken during the other days of the week these are grouped together.

In Table IX an attempt is made to portray the situation, with regard to the consumption of milk and other closely allied products, in households where children are present, and where they are absent. Persons up to fourteen years of age are included as children. It is a debatable point as to whether children on the whole take greater quantities of milk than adults.

In the good middle class households it can safely be assumed that wherever liquid milk is needed by children their needs can be met and it cannot be inferred that in this group small changes in incomes or the price of milk would have any appreciable effect upon the quantity of milk supplied to children. Moreover, only very small amounts of tinned milk are bought by this class of people. Comparing families with and without children in this group it is seen that there is no significant difference in the quantity of milk taken. It is interesting to note that in both the new housing area and in the poor working class group more liquid

TABLE IX.

Consumption per Person in Families with children. Houses not taking liquid milk omitted.

Groups.	*No. of Persons.*	*Liquid Milk.* *Pints.*	*Liquid Milk.* *Cost.*	*Tinned Whole* *Pints.*	*Tinned Whole* *Cost.*	*Tinned Skimmed.* *Pints.*	*Tinned Skimmed.* *Cost.*	*Cream and Milk Powder.*	*Total Cost.*
			d.		d.		d.	d.	d.
I. G.M.C.	181	3.80	10.7	0.05	0.25	0.04	0.08	1.6	12.53
II. G.W.C.	132	2.20	6.2	0.04	0.20	0.70	1.40	0.3	8.10
III. N.H.A.	386	1.46	3.8	0.02	0.10	0.60	1.10	0.2	5.21
IV. P.W.C.	192	1.17	3.0	0.07	0.30	0.70	1.40	0.3	5.03
Consumption per person in families without children.									
I. G.M.C.	211	3.90	10.8	0.03	0.15	0.10	0.20	—	12.15
II. G.W.C.	285	1.75	4.7	0.04	0.20	0.25	0.50	0.06	5.46
III. N.H.A.	43	2.19	5.8	0.01	0.08	0.70	1.40	—	7.28
IV. P.W.C.	99	2.08	5.3	0.07	0.35	0.80	1.60	0.06	7.31

milk is taken per person by the families without children. As the quantity of full cream tinned milk in both cases is very small it

cannot be assumed that this displaces liquid milk to any appreciable extent. With regard to tinned skimmed milk, fair quantities are purchased by households in both groups, but it is the families without children that take the largest quantities, whilst the total expenditure on all kinds of milk food is greater in families containing only adults. It is sometimes suggested that families without children are able to enjoy a higher standard of living and that it is these people, especially amongst the poor classes, who take the largest quantities of milk. It appears in some cases that when several children are present in poor homes, no additional supplies of milk foods are bought with the result that there is less for each, and when the total quantities of milk going into such homes are divided by the number of persons present results similar to those submitted in Table IX are obtained.

The analysis can be pursued, however, to the statement of the value of milk and milk foods purchased *per head* in families of different sizes, irrespective of whether the members are children or adults. The complete figures are given in the Appendix, but the summary is as follows :—

Purchases of Milk Food per Head by Size of Family.

Pence per head.

No. of Persons in Family.	*G.M.C.*	*G.W.C.*	*N.H.A.*	*P.W.C.*
	d.	*d.*	*d.*	*d.*
1	—	—	—	8.80
2	11.85	7.65	6.60	8.70
3	14.30	7.03	10.10	5.98
4	10.55	7.35	5.68	6.15
5	10.54	6.88	4.80	4.96
6	9.43	5.05	3.63	6.18
7	—	—	—	3.22

The general tendency shown is towards lower consumption per head as the size of family rises, although this tendency is interrupted at various stages in each of the groups. But perhaps the most important feature of this summary is the indication that the conditions which cause high or low consumption per head are many and various. The amount of income in relation to number of persons to be maintained is obviously one factor determining the amounts purchased, but the presence or absence of children, especially babies, is another; and still others are to be found in the differences in preferences, tastes and habits of undefined character.

PART II.

Some Conditions of Demand.

With the general facts as ascertained in the investigation in mind it is possible to discuss some of the conditions of demand for milk. In this connection some features of the daily distribution of purchases of milk during the week are important. From the figures themselves it is obvious that in all the districts there are special purchases of milk for culinary purposes on the Sunday. In the poor working class district the week-day purchases of fresh milk are almost entirely for use in beverages; and in two other districts the week-day purchases are mainly for this use. The quantities are such that with common use in beverages over the families of the three lower groups there can be very little left for any other purpose. Thus, to a certain extent, the problem of increasing the demand for milk, given sufficient purchasing power, appears to be partly one of extending the Sunday or week-end habits to other days. There is, however, reason to believe that the consumption of fresh milk and possibly of some other milk foods in the poorer districts of Cardiff had fallen to some extent in the months preceeding the investigation, and to that extent some increase in consumption requires only a return to previous habits. There is thus reason to believe that increase in purchasing power would bring renewal of some habits, and with an appreciable increase in incomes new habits might be established.

Under strong suggestion, or under education of a character that would stir the will as well as the reason, there might even be divertion of existing purchasing power to make a greater demand for milk. A new or a clearer conception of the conditions of welfare of children, or of some other individuals in special need of a milk diet, would bring such a change. For children or other persons needing milk under special circumstances such changes will be made for a short period, but the change is apt to be temporary. The habit of consumption is apt to be related to the special need and to pass with it. For children under normal circumstances some families with relatively low incomes do make special provisions even at some sacrifice of other possible purchases, but it is obvious in the lower consumption groups here dealt with that such special provision is not general. Whether lack of purchasing power or general ideas and habits are the more important in this connection it would be difficult to say, but it is obvious that stimulus to change of habit must be fairly powerful if change is to be

obtained without an increase in purchasing power. It may be assumed without much risk that an increase in purchasing power would maintain the steady, normal, consumption of milk. But it does not follow of necessity that a further increase in purchasing power would bring increased expenditure on fresh milk and its substitutes or increased consumption of fresh milk. The direction of new expenditure which may become possible is a matter of choice, and choice will be determined by desires ingrained or stimulated by suggestion, imitation, previous habit, deliberate thought—by all sorts of conditions.

Before any judgments are offered, however, attention may be drawn to what is one of the most remarkable results of the investigation. There was almost unanimous agreement amongst retailers that customers who moved to new housing estates immediately reduced their purchases of fresh milk. There was also a suggestion—of which there is no test in the records—that slow payment or bad debts tended to be more serious in new housing areas than in almost any other type of district. Both these conditions, it was stated, arose from the drain of high rents or mortgage payments on the weekly (or periodical) incomes of the occupants of new houses. The general opinion was that these conditions arise almost irrespective of the different kinds of ownership or tenancy under which the new houses may be occupied. As regards consumption, the retailers' judgments must be accepted as correct. The new housing area group of households is shown as expending less per person on fresh milk and milk-substitutes for fresh milk than the households or the good working class area, and about the same amount per person as the households of the poor working class area. It is remakable, too, that these households purchase less fresh milk and more condensed than those of the good working class : 14 per cent. of new housing area households did not purchase fresh milk as against 9 per cent. in the good working class. Thus there appears to be evidence that an expansion of requirement of purchasing power without an increase in the power itself will and does decrease the purchase of fresh milk. It is almost certain, also, that a contraction of purchasing power against normal or steady requirements of living will again decrease the purchase of fresh milk. The practical absence of the purchase of condensed milk in the best district and its occurrence, and the varying frequence of its occurrence, in the other groups obviously has an important bearing on the consumption of fresh milk and a less obvious bearing on the total consumption of milk. In the poor working

class group twenty-six households, clearly, use milk—and all condensed—mainly if not only in tea or other beverages, and almost certainly mainly in tea. In the new housing area, fourteen households and in the good working class area nine households, use milk only or mainly in this way. In these families the conditions of consumption are complex. It could not be said that lack of purchasing power is the only determinant of choice of expenditure. Some, at least, of these families who purchase only condensed spend as much on milk as others in the same groups who purchase the fresh variety, although the average expenditure per household and per person of the families purchasing condensed is much lower.

Purchasing power is one, and often the most important factor in the choice. Yet there are others that cannot be neglected. Mere ignorance must not be assigned as a cause of choice without good grounds. Some ignorance exists but it is not of a kind which is removable without sympathy and clear understanding. Families who purchase only condensed milk frequently use it only as a constituent of such beverages as tea, although it is not unknown as a substitute for jam and sometimes for butter or margarine—on the children's bread. Used only as a constituent of beverages it may be more immediately economical than fresh milk, especially where storage facilities are poor or non-existent. Chemists or dietitians, perhaps, must decide on its final economy; in the day-by-day or week-by-week budget of the poor housekeepers its economy sometimes appears obvious. This is especially the case where hours of meals are uncertain or irregular and where meals are taken during other people's normal sleeping hours. Under these circumstances, the tin of condensed milk is always ready and usually the contents are in fair condition. But beyond this there is the factor of an acquired taste for the slight " burnt milk " or " toffee " flavour in the condensed variety. This is not unknown amongst social classes other than those who are compelled to purchase it, for boys and men who go to camp and consume it there sometimes acquire the taste, or appreciate the flavour under the conditions of consumption. The principle, possibly, is that persons who do not obtain a varied dietary, or obtain food in fairly rough conditions, appreciate the stimulus to the palate given by the " toffee " flavour. In any case habitual consumers of condensed milk will not always accept fresh milk as an adequate substitute for condensed milk in beverages. Fresh milk is said to lack " flavour " or " character " and sometimes to be " sickly stuff ".

It is almost certain that a change from condensed to fresh milk, in some cases, would require to be made in connection with a somewhat general change—and improvement—in dietaries. And for this an increase in incomes or somewhat general change in conditions of living may be necessary. The most serious condition in respect of consumption of condensed milk amongst the families here dealt with is that an appreciable number of children do not obtain any fresh milk. Their tastes and habits could almost certainly be directed towards fresh milk.

It is not lightly to be assumed that an increase in purchasing power, an advertisement campaign, even a short-period demonstration, or any other single or simple specific, will increase the purchase and consumption of fresh milk. A combination of conditions and forces is almost certainly required to bring a general increase in effective demand that will remain after temporary stimuli are removed. Some families would respond to one condition or stimulus, some to another, but in all cases the first establishment of habit is required for anything like permanent change. While it appears that a change from condensed to fresh milk in the families now purchasing the former is likely to make some increase in total consumption expectations of the amount of such increase are too easily exaggerated. Increase in purchasing power as well as change of taste and habit is required before these families will make any important increase in their total milk purchases. A mere change of their present expenditure from purchase of condensed to fresh milk would increase the demand for the latter by nearly 20 per cent.

Without attempting a theoretical or an exhaustive analysis of the conditions of an increase in the effective demand for milk an indication of the general conditions is possible. A certain amount of expenditure on milk (or what may be called "milk-stuff"), in every family, is expenditure on a recognised necessity. All the 400 families purchase milk in one form or other, but only 350 or 87.5 per cent. purchase fresh liquid milk while 50 or 12.5 per cent. purchase only condensed tinned. The families which purchase other than fresh milk choose their supplies either on the basis of preference or taste, or because their means do not enable them to obtain fresh milk, or because they consider that the supplies of condensed milk obtainable with their present expenditure are cheaper and more economical. In any case, it must be presumed under present circumstances that current expenditures on the condensed variety give greater satisfaction than would be obtained from supplies of fresh milk obtainable by

an equal expenditure. This satisfaction may arise from either of these conditions : the supply may be greater, or it may be more convenient, or it may be more economical (*i.e.* may keep or last longer or " go further ") than the supply of fresh milk obtainable with the same expenditure; or the supply of condensed milk may have qualities (in the judgment of the actual consumers) such as sweetness or other flavour which outweigh other disadvantages. In this latter case it is possible that the supply of condensed milk may be smaller or less convenient or economical than supplies of fresh milk obtainable with a given expenditure, and that supplies of condensed milk will still be purchased because of special qualities. Most probably a combination of these conditions accounts for the continuance of purchase of condensed milk.

There may be, and almost certainly there is, ignorance of the relative nutritive values of fresh and condensed milk; but it does not follow that if this ignorance were removed the consumption of the condensed variety would cease, for some of the other conditions would still remain.

In considering the possibilities of increasing the effective demand for fresh milk the main changes in view will be :—

(1) Increasing purchase of fresh milk by families now buying it.

(2) Diverting the present expenditure on condensed to purchase of fresh.

(3) Increasing the expenditure on milk of families now purchasing the condensed variety.

The present expenditure on milk of any of the families is not a measure of the necessity of milk in their dietaries : it is only a measure of the comparative necessity of milk amongst the other possible foodstuffs and also amongst other requirements of living and other satisfactions which the families can purchase with their present incomes. With their present dietary habits, with their present valuations of milk as an item in the dietary, they apportion their incomes amongst many requirements. The possibilities of change of dietary habits, and in valuations of milk leading to an increased demand, vary with each group and to some extent with each family. But they also vary with the conditions of supply and the price of milk itself, and quite possibly to a small extent with the quality of the fresh milk on offer.

The important factors are :

(1) Purchasing power (or incomes) of families.

(2) The valuation of milk as an item of dietary.

(3) The quality or reliability of the milk offered (or the absence of any fears which would retard rising valuation of milk).

As regards the middle class group it must be assumed that they have adequate purchasing power for an increase in milk purchases if their valuation of milk rose. An addition of 50 per cent. to their expenditure on milk and related goods dealt with in this study would only amount to 2s. per week. With stationary incomes, even here, such increased expenditure would require curtailment of other expenditure (or of saving). A rise in the appreciation or valuation of milk must to some extent precede an increased expenditure. Such a change in appreciation might be brought about by a removal of any existing fears of dangers in milk; but, of greater importance, by a publicity or educational campaign on the nutritive values of milk. The success of any such campaign requires a series of changes in the dietary habits of the families and a rearrangement of expenditure. Alternatively, a greater quantity of milk could be sold to this group without a re-arrangement of expenditure by decreasing the price of milk—given that the means set free were spent again on milk. But a drop in the price of milk does not necessarily bring this result; it may only set free some means for expenditure on other satisfactions. An increase in consumption by reason of decrease in price also requires some change in consumers' appreciation or valuation of milk, though not so much of change as would be required with a stationary price; but it requires the same change in dietary habits.[8] Again, if an increase in incomes were postulated in this group it does not follow that it would lead to increased expenditure on milk; and it would not do so unless it coincided with a rise in consumers' valuation of milk. In this group some increase in purchase might be stimulated by a campaign of publicity or education to raise consumers' valuation which coincided with either a rise in purchasing power or a fall in the price of milk itself, or in prices of other requirements; there would be greater resistance to a rise in expenditure on milk which required re-arrangement of the present dietary budget, but there is always the resistance of dietary habits to overcome.

We are here dealing with the very vexed question of the degree of elasticity of the demand for milk. Fortunately, perhaps, the elasticity of demand for milk is not equal to unity; that is to say that an increase or decrease in price will not bring an equaal

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[8] That is, assuming that the families are already fully-fed.

decrease or increase in demand. However much the absence of unity in an upward direction of demand is to be regretted, the existence of a certain minimum demand which exists to some extent irrespective of price (*i.e.* irrespective of price within certain limits) has been an important factor in the maintenance of prices. In quite homely terms, this minimum demand represents the quantity of milk required in beverages such as tea, cocoa, and coffee and possibly for the Sunday pudding; but the minimum demand varies to some extent in different classes and in different households in any class. It represents the quantity of milk in uses for which the consumers have the strongest attachment and therefore the highest valuation. Further use of milk beyond this minimum depends on incomes, prices, and appreciations of the other uses.

In Groups 2, 3 and 4 it is obvious that a part of this minimum demand, especially that arising from use in beverages, can be satisfied by supplies of the condensed variety. This part of the demand is for what may be called "milk-stuff" and not necessarily for fresh milk. This demand may rest on ignorance, on poverty, or on taste or even on a fairly rational assessment of economy. Any change will require either increased purchasing power, or education, and quite possibly both. Any mere divertion of present expenditure of the Groups on condensed milk to purchase of fresh milk would only slightly increase the total milk consumption of the country, including milk now sold as liquid and as condensed, although it would increase the consumption of home produced fresh milk.

In Groups 2, 3 and 4, then, any increase in consumption of milk is to some extent dependent on increase in purchasing power. Free purchasing power for increasing expenditure on milk could be obtained in any of these ways (1) an actual increase in incomes; (2) a reduction in the prices of some or all requirements other than milk; (3) a reduction in prices of all requirements including milk; (4) a reduction in the price of milk alone. Assuming an increase in purchasing power from any one or more of these it does not follow of necessity that more milk will be purchased. A fall in the price of milk itself will bring some increase in the demand, but most probably not an equal one—that is to say that a fall from 7d. to 6d. a quart will not universally bring an increase from 14 to 16 or from 7 to 8 pints a week (or over a whole group —from 700 to 800 pints). There are always alternative uses for the free purchasing power, and milk must compete for the consumers' appreciation with the other things which are purchase-

able. Purchasing power set free by a fall in prices of other requirements will not necessarily be spent on milk; it is at least equally likely to be spent on other things unless there is special reason for a rise in consumers' appreciation of milk at about the time of the change. Again, for any definite increase in income which provides free purchasing power there will be competing desires and it will not necessarily be spent on milk.

In the absence of any setting free of present purchasing power or an actual increase in incomes, the possibilities of increased expenditure on milk depend on making important changes in consumers' valuation of milk, in dietary habits, and in the re-arrangement of expenditure of present incomes. The social forces of publicity, of education, of demonstration required to make such changes would be very considerable. But in any case, even with the existence of free purchasing power, the application of these social forces will be necessary. To assume otherwise is to assume that some of these forces have been at work, that their influence has been exerted, that the potential demand for milk exists, and that only purchasing power is lacking.

In all these Groups (2, 3 and 4) there is undoubtedly a certain amount of potential demand which cannot be implemented by purchasing power—first, a possibility of some change from condensed to fresh milk, second, an extension of the use of fresh milk to some uses more or less habitually followed before the industrial depression. Some appreciations, or clear recognitions of satisfactions to be obtained by greater purchase and consumption when means allow, are undoubtedly present. But effective demand arising from these would not greatly increase total demand. For this purpose, some new appreciations are required.

The probability is that the change in dietary desires and habits required to raise effective demand for milk can be made far more easily in the case of children and young people than in adults. The appreciation of the importance or of the value of milk, however, must come through parents rather than through the children or young people themselves, except in cases in which children have gained an appreciation in school or young people have gained it through other contacts. Quite possibly one of the best ways of inculcating high appreciation of fresh milk is that of supply through the schools. This, however, is not wholly effective, for it is known that the habit of drinking milk in the morning in school is not by any means always followed during holiday periods. This is partly because the need of sustenance

during the morning can be met, at home, by the supply of other foods—bread and butter or bread and jam, or biscuits—but fundamentally because the appreciation of milk has not been inculcated in the parents. The habit of drinking milk at other times of the day must, in almost all cases, be inculcated by parents. And it is to the parents that the appeals of publicity or education must be made. Most probably they would respond more quickly and fully to appeals made in respect of their children than in respect of changes in their own habits; almost certainly if change required sacrifice of other purchases and other satisfactions the sacrifice will be more commonly made for children than for any change in the sources of satisfactions for the parents themselves.

While the requirements of individual and public health, especially of children, almost certainly call for greater consumption of milk such greater consumption is dependent upon :

(1) Increase in incomes or a setting free of purchasing power.

(2) Change in dietary habits.

(3) Such change in the appreciation or valuation of milk as

will lead to change in habits, and as will lead to greater purchase with or without sacrifice of other satisfactions.

But lower retail prices of milk would assist to stimulate demand, and most probably would raise effective demand to the point at which all the uses which were covered before the industrial depression would again be covered.

APPENDIX.

Purchase of Milk Foods per Household by Size of Family. (Houses not taking liquid milk omitted).

Good Middle Class.

Size of family. Persons.	*No. of Cases.*	*Liquid Milk.* Pints	Cost. d.	*Tinned Whole.* Pnts	Cost. d.	*Tinned Skimmed.* Pnts	Cost. d.	*Total Milk.* Cost. d.	*Cream and Milk Pud'r* Cost. d.	*Total Cost.* d.
2	14	6.7	19.6	—	—	0.3	0.7	20.3	3.4	23.7
3	31	13.3	38.4	—	—	0.1	0.2	38.6	4.3	42.9
4	20	14.5	37.3	0.2	0.7	0.2	0.5	38.5	3.7	42.2
5	19	17.0	48.5	0.3	1.3	0.3	0.6	50.4	2.3	52.7
6	9	17.3	47.6	0.7	3.2	—	—	50.8	5.8	56.6
Good Working Class.										
2	22	5.0	13.2	0.1	0.6	0.8	1.5	15.3	—	15.3
3	19	7.0	18.0	0.1	0.2	1.4	2.7	20.9	0.2	21.1
4	19	9.4	24.8	0.4	1.7	1.2	2.5	29.0	0.4	29.4
5	9	10.9	27.0	—	—	3.2	6.5	33.5	0.9	34.4
6	14	8.7	22.6	—	—	3.7	7.3	29.9	0.4	30.3
New Housing Area.										
2	9	3.8	9.4	—	—	1.7	3.3	12.7	0.5	13.2
3	14	9.0	23.0	0.3	1.2	1.4	2.8	27.0	3.3	30.3
4	19	6.7	17.4	0.2	0.7	2.6	5.2	23.3	0.6	23.4
5	14	6.6	16.2	—	—	3.5	6.9	23.1	0.9	24.0
6	14	5.6	14.7	—	—	3.5	6.9	21.7	0.2	21.8
7	10	5.2	12.9	0.2	0.7	4.0	7.9	21.5	1.1	22.6
Poor Working Class.										
1	6	3.0	7.7	—	—	0.3	1.1	8.8	—	8.8
2	12	4.1	10.8	0.7	3.2	1.8	3.0	17.0	0.4	17.4
3	14	3.7	9.7	0.6	2.8	2.6	5.3	17.8	—	17.8
4	17	6.7	17.1	0.3	1.2	3.1	6.3	24.6	—	24.6
5	12	5.8	14.0	0.6	2.8	3.5	6.9	23.7	1.1	24.8
6	6	8.4	20.7	1.4	6.4	5.0	10.0	37.1	—	37.1

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CATTLE-RAISING BY "SUCKLING" IN RADNORSHIRE.

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The system of raising store cattle, mostly of a Hereford or Hereford-cross type, by suckling on cows is practised in several parts of Wales. It is a system which requires a minimum of labour and a relatively large amount of land for a given amount of value of product. The quality of land in use for this system varies from that of some of the fairly rich and sheltered portions of the Severn Valley to poor and exposed hill pastures at fairly high altitudes in other parts of Montgomeryshire and in Radnorshire and Breconshire.

Some study of this system seemed desirable, for while most agricultural systems are being intensified in one way or another very little change seemed to be occurring in this method of herd management and production of store stock. The system has been an integral part of the complete system of beef production as practised in this country. Probably it has two aspects :—(1) It has enabled the farmers who follow it on the better qualities of land to produce high quality stores for feeders and also to carry forward from birth in good condition the animals they intend to fatten on their own farms; (2) It has enabled farmers on the poorer lands to produce stores of fairly good quality. The profitableness of the system has largely depended on the price of land and on the prices of stores which are ultimately related to the prices of beef—and where feeding and store-raising have been combined, directly on the price of beef.

While it was not possible to study this system of management in all its forms, it seemed desirable to make some study of its simplest form. This is most widespread in Radnorshire and therefore a preliminary survey was conducted in that county in 1931.

Radnorshire is mountainous and rugged, a considerable proportion rising to an altitude of over 1,000 feet, and over 40 per cent. of its area is returned by the Ministry of Agriculture and Fisheries as rough grazing. It is therefore not surprising that its farming is almost entirely of a pastoral nature. By far the most important branches of farming are the rearing of store sheep and cattle, and the relative importance of the two types of stock production varies from one part of the county to another. The very dense sheep population is distributed throughout the county, but whereas there are areas in the higher and more remote

parts where sheep are practically the only form of livestock kept, there are other districts, at lower altitudes, where cattle rearing is predominant. But even on the lower ground, sheep always constitute an important proportion of the livestock carried. A very small portion of the farm is tilled, mainly for the growing of oats, barley and roots, most of which are fed to the stock. The greater part of the livestock is marketed in store condition to be finished in some more congenial parts of the country. In the lower and more accessible parts of the county, however, fat lamb production, although by no means widely adopted, assumes some importance, while in the lower districts of the county some cattle fattening, both summer and winter, is practised.

The cattle reared are almost entirely of the Hereford type, which apparently is well suited to the conditions of the county. The sheep on the higher lands consist mainly of the Radnor or Welsh Mountain breed, while Kerry or " dark faces " predominate in the lower lying districts. Many farmers run Kerrys or Kerry crosses over the better and lower parts of their farms, while the Welsh type is given preference on the hills. Of course, there are innumerable crosses, and it is a very common procedure in Radnorshire for the lowland farmers to buy Welsh sheep from the upland districts, cross them for two or three generations[1] with Kerry rams and the improved and larger sheep are then sold as "Kerry," a type much sought after by the English graziers and lamb feeders. This widely adopted system of sheep improvement frequently has brought financial success, and is a method of advantage to the livestock industry. The Radnorshire farmer occupies an intermediary position between the breeder of the small Welsh Mountain type of sheep on the one hand, and the English grazier on the other, who is provided with a very suitable type of ewe for lamb rearing.

There is very little production of liquid milk in Radnorshire, and practically all the milk produced is sold locally or converted into butter. The production of butter is a sideline of store cattle raising, sales are mainly in the local markets on a rather small scale. Dairying as such occupies an insignificant position in the county, and it is doubtful whether it would ever receive consideration were it not for the fact that frequently the women folk partly or wholly rely on its meagre returns for their house-keeping money. The pig population is small and the market confined within narrow limits. In fact, the pig population for Radnorshire is the lowest in density of any county in Wales. Very little

[1] Welsh x Kerry; Welsh-Kerry x Kerry: Welsh-Kerry-Kerry x Kerry.

porking is done, and what breeding sows are kept are used for the purpose of obtaining store pigs for local bacon requirements, and these stores are usually sold as weaners. Very little attention is paid to poultry, and it is doubtful whether poultry of any description would be allowed to appear on many farms were it not for the efforts of the women folk to increase the resources of house-keeping.

There is a large export of store sheep from the county, mainly into the West-Midland counties of England, but sheep from the west and the north-west of the county may move into parts of North Wales. South Wales is the principal market for most of the fat lambs produced and the remaining products find a local market.

The size of farms in Radnorshire runs fairly high, the average size of all " agricultural holdings " in the county being about 70 acres against a similar average for Wales of 46 acres. Only Breconshire amongst the Welsh counties has a higher average. The amount of labour engaged on farms is relatively small, for as shown by the Census figures Radnorshire has only a little over two-thirds of the average amount of labour engaged in agriculture in Wales as a whole.

Persons engaged in Agriculture per 100 Acres Cultivated Land. (Approx.).

	Radnorshire.	*Wales.*
1911	2.6	3.5
1921	2.3	3.3

Recent changes in the agriculture of the county have been : a decline in arable land; an increase in proportion of oats and decline in other cereals; an increase in cows in milk; a decrease in the older stores or feeding cattle (namely over 2 years); a slight increase in younger cattle; an increase in total sheep made up of increases in ewes and younger sheep with a decrease in the older store sheep.

The system of raising calves on cows fits into the general system of farming, which consists mainly of cattle and sheep raising. The general system of management of the cattle is a very interesting one, having been evolved to suit the particular conditions existing in the county. Although methods differ from district to district and from farm to farm, the general system is the same throughout the county. In the first place the system adopted is essentially an open-air one, aiming at a maximum reduction of cost. The ultimate object is a store animal to be sold off the farm at the most convenient time to suit the general

farming system. Numbers, rather than quality, has been the aim of the producers of store stock. It is here that the producers have often failed, for since they are far removed from the ultimate user or consumer, they have not given sufficient thought or attention to his requirements. The quality of the fat animals depends a good deal upon their treatment when young, and for this reason considerable responsibility for final quality rests with the rearers of store stock.

But the Radnorshire farmers' prime object is to rear as cheaply as possible and his system certainly recommends itself in this respect. Consequently he interferes as little as possible with the natural conditions. The cows calve in the spring mainly, as near to the time of turning out as possible, and many calve after they have been turned out. The calves run with their dams for the rest of the summer, at the rate of about one calf to one cow, and they require very little attention of any kind. They remain with the cows for about seven months on the average, April being the principal calving month and November the usual 'housing' time.

On the whole the treatment of the larger herds approaches more nearly to the above system, but there are many modifications of which a few examples may be given. Whereas the general tendency within the larger herd is for the heifers to calve first at three years, some of the smaller farmers get their heifers to calve a year, or nearly a year, earlier. The larger farmers believe in giving their heifers sufficient time to mature properly, but for the smaller farmers the waiting period before returns are available tends to be somewhat long. Again, the owners of larger herds in order to minimise the amount of labour required, endeavour to get as many as possible of their cows to calve out of doors. With the smaller herds, however, labour supply seldom makes an acute problem. Consequently the smaller farmers can often pay more attention to their calves. They arrange for their cows to calve at different periods, and thus endeavour to secure as many early spring calves as possible, for these will then make stronger yearlings by the following year. The more enterprising of the smaller farmers make every effort to do their calves well. In most cases the larger proportion of the cows in these small herds are of a milking strain and usually the calves do not run out with the cows but are suckled twice daily. In cases where the dairy requires milk some cows are retained for milking, and two calves may be put on one cow, or some of the calves may be bucket-reared. If they are well looked after these grow

fast and make good animals, but in some instances very poor specimens may result from hand-rearing. In most cases the larger farmers keep a few crossbred cows to supply the household with milk and butter; any surplus butter being sold. The calves from these cows are occasionally reared by hand, but usually by putting two calves on one cow. On the whole, however, bucket rearing does not appeal to the owners of the larger herds. Few calves have been bought or sold, but there is a tendency on the part of owners to buy more in recent years, not merely to replace losses, but in order to intensify the system of rearing.

One of the main problems at the present time is to try and shorten the non-productive period of the herd. Thus in the past the usual age for the cows to have their first calf was at three years, which necessitated keeping them a considerable time before getting any return. It is true that the owners of the smaller herds have considerably reduced this period, but the larger farmers have contended that earlier breeding is injurious to the animals' general development. Several methods have been adopted in order to overcome this difficulty. In the first place some farmers have adopted the system of breeding from older cows and selling their heifers. They keep these cows as long as they will breed, bringing an occasional heifer into the herd or buying a cow to keep up the numbers. The heifers are sold either as 'barreners,' with the steers, or as 'in-calvers,' at about two years. Probably the most interesting experiment in this direction was that of a farmer who solved the problem by getting his heifers to calve about the month of May at two years, their calves being taken from them and reared by other cows that had calved earlier in the season. And finally many farmers have acted directly and have made it their common practice to get their heifers to calve at about the age of two years, regardless of the consequences. In some cases they have gone in for earlier (seasonal) calving so that the heifers are somewhat more than two years old when they themselves calve.

The alternative to the discovery of economies in the cost of maintaining the herd is that of devising a method or methods of raising more produce with the same amount or a little extra cost. The very extensive system of rearing only one calf per cow, and allowing that calf plenty of time in which to mature, is getting a little out of date. Consequently all kinds of modifications of the old system are being adopted, and a general tendency in some districts is towards rearing more than one calf per cow in the herd. A few examples might be cited at this point.

A small farmer, who possessed only four cows, accomplished his object of rearing more calves by getting his cows to calve at an early period, for this district, namely in February. They suckled their calves for four months until June, the calves being gradually weaned on to dry food. He then bought four other calves which had come to the local market from the Cheshire district, and suckled these on the cows until November. Thus each cow reared two calves. Another farmer with a herd of only four cows did even better than this. His cows calved fairly early in the year (in March), and possessing fairly good milking qualities, they reared their calves and also provided a little milk for the dairy. Later in the season, this farmer purchased six young calves for hand-rearing. His cows provided the new milk with which to start them, and after a short time they were fed on cream-equivalent and later on a dry feed. Several of the more enterprising large farmers have been adopting the "more than one calf per cow" system. In their herds they have half a dozen cows of a milking strain, and calves are bought for these and thus the cows rear as many calves as possible. One farmer in particular asserted that ten of his cows had reared 26 calves in one season. On the average the cows of these herds are older and many of the younger cattle are sold.

But in recent years [2] the price of young calves has been exceptionally high, making it more difficult to purchase, so that the general adoption of the above system is likely to give rise to its own problems. Also these purchased calves are difficult to rear, and a certain amount of risk has to be undertaken. But the farmers have come to recognise the fact that some change from the present system is necessary. There is not sufficient turnover from the herd, and where the labour problem is not acute, *e.g.*, on family farms, the farmers would be well advised to intensify the production of their herds, and the preceding illustrations are sufficient to show that efforts are being made in the right direction.

Several of the obstacles have been mentioned, but one other is worthy of note, as it has considerably retarded progress of some big herds. This is the disease known as 'White Scour' which is so fatal amongst calves. There is ample proof that this disease is more prevalent among calves that are confined indoors, and consequently the herds which have suffered most are those where early calving has been practised. Thus many farmers who endeavoured to get earlier calves suffered considerable loss due

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[2] Up to 1931.

to this disease, and have now gone back to later calving and the outdoor system.

Except in the vicinity of the towns, where some fairly good herds of milking shorthorns are to be found, few farms possess any really good milking breeds. The majority keep one or more crossbred cows of a better milking strain to supply milk for household purposes and also some for butter-making. Butter is produced on nearly all farms, the greater proportion of the marketed butter being sold during the summer months. The principal buyers are local dealers. How little importance is attached to dairying may be gathered from the study of fifty farms from which data was obtained. On the average only 17 per cent. of the total output per cow in each herd—(net calf products plus dairy products)—was represented by dairy products. Butter consumed and sold constituted some two-thirds of this amount. However, the writer found one farm in this district where the farmer had completely changed over to dairying. All the milk from the herd of Shorthorn and Jersey cows was separated and the cream sent to a Midland dairy company. The skim milk was partly used at home for pig feeding, the remainder being sold to a few local pig-rearers.

Survey Results with Special Reference to Calf-Rearing.

The fifty farms on which this study of the principal problems of the calf-rearing industry was carried out in the summer of 1930 are all situated in and around the Radnor Valley. This area is in the form of a basin and is composed of a fairly fertile soil. It figures prominently in all the writings of Radnorshire historians. To quote Clark, " the soil in the Vale of Radnor . . . is of a dark grey colour, well adapted to the nourishing of grain and grass, to which it is alike congenial." [3] Williams also speaks of this district in his writings on Agriculture, " the Vale of Radnor in the Eastern extremity of the county, is basin-like in shape, with a flat surface, which in ancient times was a large lake surrounded by an amphitheatre of hills." [4] The soil of this valley is of a gravelly nature containing some loam. Its one river, the Somergil, in dry weather disappears for a part of its course, due to an underground channel through the sandy subsoil.

From an agricultural point of view the Radnor Valley is very important, its farming is well developed and resembles more

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[3] Clark. Report on Agriculture for Radnor. 1794.
[4] Rev. J. Williams. History of Radnorshire. 1810.

closely the English than the Welsh type. Its farms are large and well looked after, the pastures are some of the best, and in general it appears to be a very prosperous agricultural district.

The farms range in size from 40 to 500 acres, the average being 178 acres. For convenience in interpreting the results, two classifications have been taken; (1) Size :—Farms above and below 150 acres, and (2) Altitude :—Highland and Lowland farms. These two classifications do not differ very much, as the farms less than 150 acres are practically all within the highland group, whilst the 20 farms of the lowland classification are nearly all big farms.

TABLE I.

Size and Value of Herd by Group Classification.

Group.	*Number of Farms.*	*Average size.*	*Size of Herd.*	*Average Value per Cow in Herd.*
		Acres.		£ s. d.
Highland Farms	30	149	10.8	14 13 6
Lowland Farms	20	223	19.5	16 5 0
Less than 150 Acres	24	91	8.4	14 19 2
More than 150 Acres	26	259	19.8	15 19 0
All Farms	50	178	14.3	15 13 4

The herds range in size from 3 to 45: the average number for all herds being 14. Twenty-one herds exceeded this average and the remainder were below it. Table I shows the size of herd in relation to the size of farm, and also the difference in their size as between Highland and Lowland farms. It will be seen that size of farm is a very decided factor in determining the size of the herd; the marked difference in size of herd between highland and lowland being mainly due to the difference in size of farm.

Practically all the cows are of the Hereford or Hereford-cross breed—a useful commercial type and fairly hardy. In practically every case pure-bred Hereford bulls are kept and some of these are registered under the Ministry of Agriculture's Livestock Improvement Scheme. The average age of the cows in all the herds is a little less than five years, *i.e.*, on the average they would have had two calves. Thus, generally speaking, the herds are comparatively young. A few farms, however, retained their cows for a longer period. The upkeep of the herd under this system does not give rise to many problems as practically all the

cows are home-bred. In fact, of a total of 715 cows, 98 per cent. were home-bred. Heifers are brought into the herd at two or three years to replace cows sold, or any that may have died. The herds are kept fairly constant as regards numbers. Occasionally the farmer will purchase a cow for milking purposes, either to "help the dairy" or to rear an extra calf. Since most of the cows are home-bred, and the average age of the herd is low, it is not surprising that depreciation due to loss should be comparatively low. In fact, in this group, during the year under consideration, only 18, or 2.5 per cent. of the total number of cows died. In value this represents £5 per herd or 6s. 11d. per cow.

In Table I the average value of cows in all herds is seen to be £15 13s. 4d.; and the variation as between highland and lowland is shown to be considerable and also between large and small farms.

Systems of Herd Management.

The system of herd management of these 50 herds was found to be typical of the county as a whole. It is essentially an outdoor system. The winters, however, are rather long, and the majority of the cows are 'housed' at night during this season, the period indoors varying from four to seven months. Thus the average period for the lowland farms is about 5½ months (beginning of December to mid-May), and on the higher farms it is 6½ months (beginning of November to mid-May). There is a tendency with some of the lowland farmers to leave their cows out all the winter. On the average the herds are fed indoors for about six months. Their winter rations, however, are not very costly. They are wintered 'hard,' being fed principally on oat-straw and poor hay. A little time before calving they are given a better hay ration and a few roots, if the latter are available. The principal calving month is April, and nearly all the calves are born during the three months March to May.

The summer management is simple. Where the calves run out with the cows, the latter get nothing but their pasture, and each cow rears one calf. They live cheaply, for they do not always get the best land and seldom any aftermath. With this system of management there is a low labour requirement. When the calves are suckled indoors, however, this item of cost is somewhat higher, for the suckling must be supervised. When two calves are suckled on one cow, or hand-rearing is practised, special attention is needed if good results are to be obtained.

The time of weaning depends a good deal upon the system of rearing. When the calves are 'suckled-in' they are usually weaned at five to six months old (as early as possible in most cases), so that a little milk may be obtained for the household during the autumn and winter months. The calves that run out with the cows are not weaned until 'housing time,' which is about mid-November on the average; thus they may be seven to eight months old at weaning time.

Cost of Herd Maintenance.

It has been indicated in the above description that the aim of the farmer is to rear his calves as cheaply as possible. Consequently the system adopted is one which keeps the herd maintenance cost at a fairly low figure. The average cost per cow in herd on the fifty farms is £7 12s. 0d. per annum. This amount covers pasture, winter rations, labour, depreciation and bull service, as is shown in Table II.

TABLE II.

Cost of Herd Management.

	Cost per Cow in Herd. £ s. d.	*Per cent.*
Pasture	2 6 0	30.4
Hay .	1 9 6	19.4
Straw	0 15 6	10.2
Roots	0 13 7	8.9
Corn, Cakes and Meals	0 3 8	2.4
Labour	1 9 11	19.7
Depreciation	0 6 11	4.6
Bull Service	0 6 9	4.4
Total	7 11 10	100.0

The winter rations—hay, straw, roots and concentrates—account for 41 per cent. of the cost. Labour takes third place with this system of management, and accounts for but one-fifth of the total cost per cow. This is as would be expected, since, in practically every case, the farmers assert that the main idea influencing their system of management is that of rearing calves with little labour cost. This is the first item they study when contemplating any change of method. Depreciation is another very low item in the total cost. It was previously stated that the average age of the herds is low and that in most cases the cows are sold out when fairly young, when they are still at their best. Consequently there are few losses and little depreciation of the herd.

With this system the purchasing of feeding stuffs is reduced to a minimum, and in consequence this item is relatively unimportant. A little concentrates may be given to the milking cows, but for the remainder they are fed entirely on home-grown food. There is not much difference in the cost per cow on highland and lowland farms; but when the herds are studied according to size there is a substantial difference. Thus the cost per cow is 18s. higher on the farms below 150 acres than on those of 150 acres and above. The smaller farms—and these are mainly family farms—use more labour and consequently have a higher labour cost per cow.

TABLE III.

Cost of Herd Maintenance by Group Classification.

Group.	*Cost per Cow.* £ s. d.
All farms under 150 Acres	8 0 11
All farms over 150 Acres	7 7 11
All Highland Farms	7 11 0
All Lowland Farms	7 12 4
All Farms	7 11 10

Products of the Herd.

Under dairy products is included milk and butter sold and consumed. Most farmers sell a proportion of the butter produced, but only three farms sell milk. Practically all the whole-milk is for home consumption, and the total estimated value of this product (at 1s. per gallon) is £377 5s. 0d., or £7 11s. 0d. per farm. There is relatively little consumption of whole-milk on these farms, except on those farms where there are large families.

The total amount of butter sold and consumed during the year was 13,572 lb. or 271 lb. per farm. Four farms produced none, whilst production on the remainder ranged from 44 to 644 lbs. The average price received for butter sold was 1s. 2d. per lb. and the total value of butter produced was £791 12s. 11d., or 11.8 per cent. of the total dairy products. Most of the sale butter is marketed during the six months April to September; May and June being the principal months. On the whole very little butter is produced during the winter, and on many farms there is scarcely enough to supply the household. Since there is little levelling out of the calving period, it follows that the late

spring and early summer are the flush periods of milk and butter. Dairy produce accounts for 17 per cent. of the total net output (dairy produce and calves sold and reared, less calves bought) of all the herds. The smaller farms pay more attention to this line of production as the following Table shows. In this group, farms less than 150 acres produce twice as much dairy produce per cow as farms above 150 acres. The margin of difference is considerably less when the highland and lowland farms are compared, but here again the output is greater in the case of the former group.

TABLE IV.

Output of Dairy Produce by Value.

Group.	*Total Output of Dairy Produce.*	*Per Cow.*
	£ s. d.	£ s. d.
Highland Farms ...	615 6 3	1 17 10
Lowland Farms ...	608 3 8	1 11 2
Farms less than 150 Acres ...	536 17 3	2 13 5
Farms more than 150 Acres	686 12 8	1 6 8
All Farms	1,223 9 11	1 14 3

Calf-rearing being the primary object of the store cattle enterprise in this district, it is natural that this business constitutes the greater proportion of the output of the herd, in fact, it accounts for 83 per cent. of the total net output. Calves born averaged 0.98 per cow in herd, or deducting the 22 that died, the average is 0.95. Thirty-three calves were sold and sixty bought. Thus the gross calf yield (calves reared and sold) per cow by number is 1.04. The average gross value of all calves sold and reared is £8 6s. 0d., so that the average gross value of calves per cow in herd is £8 6s. 0d. × 1.04 = £8 12s. 6d. In order to arrive at the total net calf figure, the sixty calves purchased must be deducted from the 743 calves sold and weaned. This leaves 683, or 0.96 per cow. The average net value of all calves sold and weaned was £8 13s. 10d., so that the average net value of calves per cow is £8 13s. 10d. × 0.96 = £8 6s. 1d. The net calf output per cow in individual herds ranged from £4 11s. 5d. to £11 10s. 0d. In the latter case the herd had helped to rear ten calves, six of them having been purchased.

There is no substantial difference in the result when the size of the herd is considered, as will be seen in Table V, but there is a slightly larger net output of calves per cow on the larger farms.

The highland and lowland classification, however, reveals a substantial difference, the net calf output per cow being 16s.

TABLE V.

Net Value of Calves per Cow.

Group.	*Net Value of Calves per Cow.* £ s. d.
All Highland Farms	7 17 3
All Lowland Farms	8 13 4
Farms 150 Acres and less	8 3 3
Farms over 150 Acres	8 7 4
All Farms	8 6 1

more on the lowland farms, the latter group consisting of the larger and better herds.

The total net value of products per cow is arrived at by deducting the value of the calves purchased from the gross value of products per cow.

	£	s.	d.
Gross Value of Product per cow	10	6	9
Less calves purchased per cow . .	0	6	5
Net value of product per cow	£10	0	4

Dairy produce accounts for £1 14s. 3d. of this amount, and calves (sold and weaned) £8 6s. 1d., or 17.1 per cent. and 82.9 per cent. respectively.

TABLE VI.

Net Value of all Products per Cow.

Group.	*Net value of all products per cow.* £ s. d.
All Highland Farms	9 15 2
All Lowland Farms	10 4 6
Farms 150 Acres and less	10 16 8
Farms over 150 Acres	9 14 0
All Farms	10 0 4

The net value of all products per cow is higher on the lowland farms than on the highland farms. This is accounted for by a higher net calf output in the former group, since dairying is

somewhat more important on the highland farms. It is also interesting to note that whereas the net calf output per cow was higher on the larger farms by 4s. the total net output per cow is smaller by £1 3s. 0d. This again indicates the greater importance attached to dairying on the smaller farms.

The results obtained by classifying the herds acacording to size are quite interesting.

Size of Herd.	*Net value of produce per cow.* £ s. d.
3—9 (inclusive)	11 8 0
10—19	9 11 8
20 and over	9 16 6

The middle group have the least output per cow, whilst the smaller herds have a substantial margin over the larger herds, due to higher calf and dairy output. The larger herds produce better calves, which increase their net calf output figure, whilst the average sized herds are neither outstanding in dairy produce nor calf output.

Balance or Surpluses.

The surplus is arrived at by deducting the cost of herd maintenance from the total net product. For these fifty herds, the average surplus per cow is £2 8s. 6d. Not all farms show a surplus as, on several farms, there is a negative balance, the highest of these being £2 4s. 6d. per cow in herd. A study of these seven farms reveals the nature of the loss, for it is significant that five of them have high costs due to losses of cows; that is, depreciation considerably increased the expenses of the herd.

TABLE VII.

Cost of Herd Maintenance, Net Value of Product. and "Surplus."

Group.	*Cost of Maintenance per cow.* £ s. d.	*Net Value of Produce per cow.* £ s. d.	*Surplus per cow.* £ s. d.
Highland Farms	7 11 0	9 15 2	2 4 2
Lowland Farms	7 12 4	10 4 6	2 12 2
Farms 150 Acres and less	8 0 11	10 16 8	2 15 9
Farms above 150 Acres	7 7 11	9 14 0	2 6 1
All Farms	7 11 10	10 0 4	2 8 6

The farms in the lowland group show a larger surplus than those of the highland group; the costs are approximately the same, so that the difference is due to a higher output on the lawland farms, *i.e.*, a higher calf output, as the output of dairy produce is somewhat higher on the highland farms. The surplus per cow is nearly 10s. higher on the farms below 150 acres than on the larger ones. Thus, although the cost of maintenance per cow is more on the smaller farms, yet this is more than balanced by a much higher net product per cow, which in a previous section was shown to be due to the greater importance of dairy products on the smaller farms.

Types of Cattle Sold.

It remains to be seen what numbers and classes of cattle are finally sold from these farms. The foundation herds, it will be remembered, contain 715 cows. Allowing for all losses up to time of sale, the annual sales of all cattle amount to about 690 (or 96 per cent. of the number in the foundation herd). The chief purchases are of calves for rearing, but some young calves are also sold. Allowing for net purchases, the final sales from the foundation herd represents in numbers about 94 per cent. of the foundation herds. But it must be borne in mind that the herds have to be maintained and that some young cows are drafted in for maintenance.

At the present time there is a definite movement towards the earlier selling of the store cattle. As a result, the two-and-a-half or three-year-old steer has been replaced by the yearling or two-year-old. The smaller farmers were the first to adopt the idea of producing a younger animal, mainly because they were not in a position to keep them longer. The larger farmers are making it their practice also. Consequently the latter aim at selling out their stores at one-and-a-half or two years, and the small farmer at approximately one year.

The fifty farms studied are fairly representative of the county. The group contains farms ranging from 40 to 500 acres and includes highland and lowland farms. An analysis of the cattle sales for one year (1930-31) reveals the nature of the disposal of the stock, as described above, and also the extent of the change over to earlier selling. The sales are classified into categories :—Calves, yearlings, two-year-olds, fat-cattle and store cows.

Calves.—Out of a total of 690 sales for this group, only 35, or 5 per cent., is represented by calves. **Most of these sales**

consist of calves sold with their dams, very few being disposed of separately (six only were sold for veal, and these averaged £6 15s. 0d. apiece). The store calves averaged £4 14s. 0d. each; this is a valuation figure since most of them were sold with their dams. In value the calves account for 1.5 per cent. of total cattle sales.

Yearlings.—This class represents nearly 50 per cent. of the total sales by number and a little over 40 per cent. of the total receipts. About half were spring sold, and the remainder in the late summer and autumn. As the following table shows, there is a substantial difference in the prices received between these two periods.

TABLE A.

Cattle Sales Analysis. All Farms.

	Number.	*Per cent.*	*Total Value.* £ s. d.	*Per cent.*	*Value per head.* £ s. d.
Calves ...	35	5.1	177 2 0	1.5	5 1 0
Yearlings:					
Spring ...	176	25.5	2,274 2 8	19.9	12 18 0
Autumn ...	149	21.6	2,148 15 0	21.4	16 8 6
Total ...	325	47.1	4,772 17 8	41.3	14 10 0
Two year olds ...	107	15.5	1,861 12 6	16.3	17 8 0
Fat Stock:					
Two year olds ...	90	13.0	2,313 18 0	20.2	25 14 0
Cows ...	55	7.9	1,089 5 0	9.5	19 14 6
Total ...	145	20.9	3,402 18 0	29.7	23 9 6
Store Cows ...	78	11.3	1,273 2 6	11.2	16 6 6
Total ...	690	100.0	11,437 12 8	100.0	16 11 6

Yearlings represent 60 per cent. of the total sales by numbers on the highest farms and 36 per cent. on the lowland farms, and

the average value per head is much higher on the lowland than on the highland farms. This is because the majority of the lowland farmers sell their yearlings in the autumn, while the smaller hill-side farmers endeavour to get them out in the spring.

Two Year Olds.—Heifers account for most of the two year old stores in this district, although a few steers are kept till the second spring. By number two year olds constitute 15.5 per cent. of total sales, 88 per cent. of which come from farms above

TABLE B.

Cattle Sales—Highland and Lowland Farms.

	Number.	*Per cent.*	*Total Value.* £ s. d.	*Per cent.*	*Value per head.* £ s. d.
Highland (30 Farms):					
Calves	14	4.4	59 15 0	4.4	4 5 0
Yearlings	190	60.2	2,495 12 6	57.1	13 2 8
Two year olds	60	19.0	992 10 0	22.7	16 10 10
Fat.					
Calves	2	0.7	16 0 0	0.4	8 0 0
2 and 3 year olds	4	1.3	85 0 0	1.9	21 5 0
Cows	2	0.7	35 5 0	0.8	17 12 6
Store Cows	44	12.9	686 7 6	15.7	15 12 0
	316	100.0	1,370 10 0	100.0	13 16 7
Lowland (20 Farms):					
Calves	15	4.0	76 15 0	1.1	5 2 4
Yearlings	135	36.2	2,227 5 2	31.5	16 10 0
Two year olds	47	12.5	869 2 6	12.3	18 9 10
Fat.					
Calves	4	1.0	24 12 0	0.3	6 3 0
Two year olds	86	23.0	2,228 18 0	31.6	25 18 1
Cows	53	14.2	1,054 0 0	14.9	19 17 9
Store Cows	34	9.1	586 15 0	8.3	17 5 2
	374	100.0	7,067 2 8	100.0	18 18 0

150 acres in size. By value they account for 28 per cent. and 12 per cent. of cattle on highland and lowland farms respectively, and they average £2 per head more in the latter than in the former group.

Fat Cattle.—This group consists mainly of cows and two year old cattle. Very little feeding is done on the highland farms; occasionally they winter fatten a few cows. Several of the lowland farmers of this district do some feeding—mainly summer feeding. Two large farms, however, account for nearly one-half of the total fat cattle receipts of this group. These two farms go in mainly for summer fattening and sell out two-and-a-half year old animals in the late summer or autumn.

Cows.—There were 78 sales of cows, approximately 50 per cent. of these being sold with their calves. The remainder were disposed of as 'barreners.' The highland farms account for the majority of this class of sales, for most of the lowland farmers feed their cows. There is no definite selling period for cows, sales taking place any time at the convenience of the farmer. The practice, however, as regards cows sold with their calves is to sell as soon after calving as possible.

Conclusion.

The analysis of the data collected from the fifty farms, where calf-rearing is practised, suggests that the farmers' main object is to keep costs down to a minimum. Consequently the output per cow is low. Very little attention is paid to dairying, and in most cases the farmers are satisfied with a calf output which represents approximately one calf per cow.

By what methods improvements in the system could be achieved, under present day conditions, it is difficult to say. It is significant, however, that some of the farmers are dissatisfied with the present system of management. They are seeking for modifications whereby output may be increased, and greater use made of the available land and labour. The out-door system of calf-rearing may have its advantages, but undoubtedly it is wasteful. Even at the present time the easy-going method is giving way to more complicated but more productive systems. A number of these have been described with a view to illustrating the kind of changes taking place.

Some of the more severe obstacles to progress in this direction have also been mentioned, such as the difficulty of purchasing good calves, and consequently the tendency to buy inferior animals which may develop into poor specimens of stores. Again there is a considerable amount of risk involved in rearing these bought-in calves. The risks attached to the indoor as contrasted with the outdoor system of rearing are also important limitations to any change.

There have been rapid changes towards the earlier selling of the stores and most probably further changes will take place in this direction, with the result that the whole system of store cattle rearing in the county will be considerably modified in the near future.

LAND IMPROVEMENT AS AN INVESTMENT.

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In 1988 I got some results of the work done in 1931 which seemed to me instructive. The first was an analysis of the best of the fields "junkered" in 1931, made by Mr. William Davies. This showed that by the combined use of 6 cwt. North African phosphates, 1 cwt. mixed cleanings consisting largely of wild white clover, and a good rub with poles bound with iron wire from old ships, a sward which started as (and remains on untreated sward) Nardus and Molinia 54 per cent., fog and bent 21 per cent., crested dogstail and white clover nil, could be changed into a sward containing

Nardus and Molinia	3 per cent.
Fog and bent (mainly fog) .. .	38 per cent.
Crested dogstail	21 per cent.
White clover	34 per cent.

The particular field on which this analysis was made is let with other fields of a much better quality, so no economic data from letting value can be derived from it.

There were, however, two lots just across the road of which no analysis was made, but which were obviously not quite as good as the field analysed. These fields even in these times of low prices averaged a letting value per acre for land tractored, phosphated and sown with cleanings of 19s. per acre. In each there was some woodland which is deemed to have no grazing value, though it has some value as shelter for stock.

Assuming that the original letting value of the treated land was, before treatment, 5s., we get 14s. an acre gross increase. This has to be divided between the cost of after treatment, to keep up the letting value, and writing off the expenses of the original treatment, which cost £8 per acre. These lots were

11 and 14½ acres of treated land, or 25½ acres in all. Cutting bracken and other rubbish is a necessary yearly charge against the gross increase of 14s. In this case about one-third or say 8 acres would be bracken infested. To cut that twice would mean say 7s. an acre, a total cost of 56s. Averaged over the whole 25½ acres this would be 2s. 3d. an acre. The parts not bracken infested need gutter cutting and gutter clearing, which brings the total clearage cost to an average of 3s. an acre.

Taking this 3s. from the original gross increase of 14s., there remains 11s. Out of this something has to be set aside to replace the North African phosphates. This may perhaps be fairly estimated at 3s. an acre. Deducting this other 3s. there remains 8s. to write down the original outlay of 60s. This means that in 7½ years from 1931 the treatment costs will be written off. The owner would then get a gross 19s., less original rent, 5s., and a treatment charge, which would then be lower owing to the bracken being killed out, say in all 5s. an acre, that would be 9s. an acre.

Approximately then, the land improver puts down £3 an acre, waits 7½ years to get it back, and then has 9s. a year for an indefinite number of years. For those who can afford to wait 7½ years the investment does not seem a bad one. It is comparable in some ways to Savings Certificates. If you capitalise the 9s. a year at five years purchase, when the 7½ years run out you get 45s. on an outlay of 60s.

But a great deal has to be paid in taxation, from which Savings Certificates are free. The risk is, of course, greater, being divided between the risk of a failure of "take" and the risk that prices of stock will keep low, and consequently the price of improved land will drop.

In 1933 I did in all some ten acres of this class of land in fourteen different lots averaging less than an acre each, the idea being to test as many kinds of land as possible. I used an Aitkenhead harrow instead of wire-bound poles in all cases but two. Owing to the dry summer the results look quite unpromising, but against that those done in 1931 looked unpromising in October, 1931, and improved afterwards.

In 1933 I did some other work, which has stood up to the dry summer and seems quite promising.

There were three lots, one 2¼ acres, one 2½ acres and one 3¼ acres, each more than a mile from the others.

They were all ploughed and sown with heavy sowings of clover cleanings. Each was part of a larger area and each was

grazed whenever stock happened to be turned on this larger area. Each had 6 cwt. North African phosphates to the acre. I estimate the letting value of the land before anything was done as 15s. an acre in each case.

The $2\frac{1}{4}$ acre lot had 52 lb. of threepenny cleanings (per lb.) to the acre costing 13s. and no other seed. This lot was put to a pretty severe test, for not only were my own sheep turned on it in rotation, but the field was grazed for two nights in September by several hundred tacked hill sheep. Ponies went on it from time to time. There are bare patches to the extent of perhaps 15 per cent. On this lot fog has come in from buried seeds to a greater extent than I should have wished. There is enough to give a good deal of winter keep. It is easily worth 30s. an acre now and probably 40s. I have had an estimate of 60s. from an experienced person. The only after care costs in this case will be cutting thistles and replacing phosphates.

The $2\frac{1}{2}$ acre lot had the same amount, 52 lb. of 3d. cleanings. These were estimated by Mr. Saunders as equivalent to $7\frac{1}{2}$ lb. of average wild white clover seed as sold by reputable firms. The field grew an immense crop of thistles, which were twice mown. These thistles undoubtedly protected the seedlings from unduly hard grazing. There is more bare ground, say 30 per cent. in this lot, but practically no Yorkshire fog infestation, as the field is drier than the $2\frac{1}{4}$ acre lot.

The letting value at present is rather under the $2\frac{1}{4}$ acre lot as there is less winter keep, but there is a prospect of a much higher leguminous percentage in a couple of years from now. The after care required is a lot of work at thistles and replacing phosphates.

The $3\frac{1}{4}$ acre lot had 32 lb. of 3d. cleanings, 14 lb. of perennial rye-grass left over from 1932, and 8 lb. of rape per acre. Thistles were very abundant. The rape had to be grazed early, as it was overshadowing the clover and rye-grass. The latter were weak owing to drought. The rape sprouted after the grazing, and later in the season gave quite a bite. The thistles were mown twice. This lot is much drier than either of the others, and is really as "dry" as any field in the district.

I should judge the bare ground as about 20 per cent., but the clover is spreading rapidly. There is no fog infestation. The after care will be thistle cutting and replacing phosphates. The letting value would be about the same as the $2\frac{1}{4}$ acre lot. During this summer this $3\frac{1}{4}$ acre lot gave much less grazing, apart from the rape, than either of the others. Indeed, owing to the dryness

of the field, there was nothing there to graze until rain came in October. After that the clovers and grasses made a good growth.

The objects I had in mind in laying down these three lots were :—

(1) To see how far land of different types could be laid down to grass without fencing off and whilst allowing the normal head of stock to graze to the usual extent on the paddocks in which the ploughed areas were situated.

(2) To see whether clover stood up to the grazing animal better than the grasses.

(3) To see whether the equivalent of 7½ lb. of wild white clover gave a high leguminous percentage in the sward.

The answer to question (1) is, so far as these three lots are concerned, very distinctly in the affirmative. I have not had them analysed, but they are anyhow good swards for letting. When sheep were turned into the paddocks of which they were part, they crowded on to them in preference to the unploughed residue. I have never tried any of them with cattle, and up to now I have never grazed them closely with ponies. On No. (1) at any rate both cattle and ponies will be turned very soon, as the Yorkshire fog is getting too thick in many places.

I did not get a good answer to the second question, because on the lot of 8¼ acres on which perennial rye-grass was sown the thistles were so thick as practically to make a protective covering for the grasses which was proof against the grazing animals.

I cannot expect an answer to the third question until the swards are analysed in the summer of 1935.

I should estimate the financial returns as about the same as in the case of the land done in 1931. If this is right it would be equivalent to a sort of special Savings Certificate, under which, for every £100 invested one got one's £100 back without interest in annual payments of about £13 in 7½ years, and then got another £100 back by annual payments of about £18 in another 7½ years. It is, of course, a long range investment, but it might suit a certain class of investor.

The advantages which may be claimed for this system of ploughing up small areas which are part of larger areas grazed as separate units are as follows :—

(1) As the worst patches are selected for ploughing, and as after ploughing these are grazed more intensively, there is a tendency to more equal grazing over the whole paddock, and there are fewer neglected and unpalatable areas.

(2) If this policy were pursued year after year there would

always be in each paddock an area predominantly leguminous to which animals could go when needing a ration with a higher calcium content than that obtainable from ordinary old sward.

(3) The formation of mat on pastures can be studied and probably can be coped with. I have been greatly surprised at the quickness of mat formation. To test this I use an ordinary "bulb planter," which picks up a bit of sod two inches in diameter and three inches deep. On a bit of sod picked up in this way the thickness of the mat which has formed can be measured with a fair degree of accuracy.

The area of 2½ acres above mentioned was ploughed in the first months of 1933 and sown in the spring of 1933. It had some unpalatable patches which were hardly grazed at all. This was probably due to a wet subsoil, for the patches were to some extent rush infested. By October, 1933, mat formation was easily observable on these patches. Fog had grown thickly and had begun to decay at the base of the stems, giving from one-eighth to a quarter of an inch of brown semi-decayed matter. This entirely prevents the growth of clover and prevents any sunlight reaching the earth.

It remains to be seen whether any modification of the Schneider Kleeberg treatment with a mixture of lime, charcoal, salt and earth will render these patches palatable.

I am inclined to believe that they will have to be pared with some implement and resown with clover seeds. They are quite small.

(4) Large " lands " or enclosed areas joining the hill could by this method be gradually improved, as the occupiers were able to spare labour and teams for the work.

(5) The U.S.A. farming policy of throwing forty million acres out of arable cultivation is probably the precursor of a similar policy in parts of the British Empire. When arable cultivation ceases on considerable areas, it is important that those areas should not become derelict and scrub infested, but that they should be kept in a fertile condition for future use without depressing agricultural markets by turning out more products than can be sold. The discovery of the technique for inoculating the land with nodule bacteria will enable wild white clover to be grown successfully almost everywhere. White clover is suitable for turning out relatively small quantities of high quality products.

If arable areas can be made to grow predominantly white clover swards without the expenses of enclosure, this may help to solve one part of the world agricultural problem.

SEED YIELDS OF PEDIGREE AND COMMERCIAL GRASS STRAINS.

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An impression prevails that leafiness in grass strains has a negative correlation with seminal reproduction, and yet this idea is supported by very little published data, that is, data from *ad hoc* experiments conducted over a number of years to ascertain the relative yields of seeds from stemmy and leafy types within a species.

The experiment discussed in this paper was laid down on a modest scale in order to obtain some measure of comparison with regard to seed yields between grass strains bred at the Welsh Plant Breeding Station and commercial strains.

Scheme of the experiment.

Eight pedigree strains were studied; two strains of perennial rye-grass, two of Italian rye-grass, and one each of cocksfoot, timothy, meadow fescue and red fescue. The corresponding commercial strain of each species was used as standard.

It must be mentioned that although the pedigree strains used in this experiment are definitely superior to commercial strains, they were in the early stages of breeding, and some of them will be replaced at the marketing stage by more highly bred strains incorporating a greater complement of desirable qualities.

The land available for the experiment was of only moderate fertility, and the area utilized for the rye-grasses was slightly better than that on which the other species were grown. A root crop was grown on each area in the preceding year. Triplicate plots of each strain were laid down and each plot covered an area of 1/100th acre net. The rates of seeding, and the scheme of manuring, are shown in Table I.

The seeds were sown on the flat in drills two feet apart without a cover crop. This is the standard method adopted at the Station for multiplying stock seed of pedigree strains. The seed rates given in Table I were adjusted so that the same number of viable seeds would be sown for each strain within a species. These seedings are quite ample for average conditions, and allow a margin to meet conditions of weather which may be unfavourable for establishment.

Mustard seed at the rate of half-a-pound per acre was mixed with each type of seed, to produce indicator plants which mark out the drills for cleaning operations in the initial stage of growth.

TABLE I.

Showing (a) rates of seeding, and (b) quantities of the fertilizer applied.

Species.	*Rate of seeding (lb. per acre).*	*Nitro-chalk (cwt. per acre).*		
		1931	*1932*	*1933*
Perennial rye-grass	6	—	8	—
Italian rye-grass	7	—	8	—
Cocksfoot	5	4	8	4
Timothy	4	—	3	4
Meadow fescue .	6	—	1	2
Red fescue	6	—	1	2

The fertilizers were applied in each year during the first week of April, after roto-tiller cultivations. When nitrogen was applied, half of each plot was left unmanured, so that the influence of this element on the seed yields of different strains could be studied. A buffer row separated the two halves of each plot treated differentially.

A basic dressing of 5 cwt. per acre of basic slag and 5 cwt. of kainit was applied to all the plots in the spring before the third seed crops were harvested.

Results.

(*a*) *Seed Yields.*

Two seed crops only were taken from the rye-grasses, and three successive crops (1931-33) from stands of the other species.

The average yields of seed for each year, the relative total yields, the relative weights of individual seeds calculated on the basis of the average weights of 1,000 seeds and average harvesting dates are shown in Table II.

In considering the yields of the first harvest year, as shown in Table II, it will be seen that the average weights of seeds from the pedigree strains are only significantly lower than those of commercial strains in the pasture type of rye-grass, the hay type of cocksfoot, and the pasture type of meadow fescue.

The weight of seed from the first harvest of commercial timothy is not included in the table on account of the excessive

TABLE II.

Showing (a) weight of seeds in grams; (b) relative yields under best treatment with commercial strains at 100; and (c) dates of harvesting.

Strain.	*1931.*		*1932.*		*1933.*		*Relative weight on the sum of two or more harvest years, commercial at 100.*		*Average harvesting dates 1931 and 1932.*
	Without nitrogen.	*With nitrogen.*	*Without nitrogen.*	*With nitrogen.*	*Without nitrogen.*	*With nitrogen.*	*Total yield of seed.*	*Individual seed.*	
Perennial rye-grass:									
Commercial	6444	—	1486	1894	—	—	100	100	18th July
Pedigree hay	6253	—	1812	2290	—	—	102	98	18th July
Pedigree pasture	3888	—	1126	1670	—	—	67	80	7th Aug.
Italian rye-grass:									
Commercial	5219	—	2568	3504	—	—	100	100	30th July
Pedigree hay (*a*)	5278	—	2566	3274	—	—	98	100	30th July
Pedigree hay (*b*)	5440	—	2762	3710	—	—	105	106	30th July
Cocksfoot:									
Commercial	2784	2959	4383	6511	3129	4203	100	100	17th July
Pedigree hay	1966	2198	3136	5742	3001	6514	106	91	27th July
Timothy:									
Commercial	—	—	2581	3870	110	130	100*	100	14th Aug.
Pedigree hay	2885	—	4468	5739	1897	3699	210*	91	25th Aug.
Meadow Fescue:									
Commercial	4685	—	1683	2016	664	679	100	100	20th July
Pedigree pasture	3346	—	828	1336	657	695	73	93	26th July
Red fescue:									
Commercial	3077	—	3055	3231	1125	940	100	100	16th July
Pedigree	3785	—	1897	1833	587	459	86	106	12th July

* 1932 and 1933 yields only.

shedding which occurred before harvesting. It is, however, questionable whether the yield, even if harvested at the optimum date, exceeded that of the pedigree timothy, firstly, on account of the very heavy infection of rust which of necessity must have reduced the seed yield, and secondly, in view of the fact that the pedigree strain produced 21 per cent. more fertile tillers. The pedigree timothy was practically free from rust throughout the experiment.

In 1932 significant reductions in seed yields occur in the rye-grasses, meadow fescues and pedigree red fescue, and definite increases in yields of timothy and cocksfoot seed in comparison with 1931 figures. One interesting feature of the rye-grass yields for the second harvest year is that the Italian rye-grass strains have maintained the weight of seed relative to the first harvest weights much better than the perennial rye-grass strains. The weaker straw of perennial rye-grass, as compared with Italian, and the relatively heavy rainfall of July, 1932, during the period of seed development, have undoubtedly influenced this result. It would not be out of place to mention further in this connection that a pure stand of pedigree Italian rye-grass covering one acre broadcast under oats at White Hopton, Montgomery, in 1931 produced an excellent crop of seed in 1932, and again in 1933 gave a crop of seed amounting to 70 per cent. of the first harvest crop, with the help of farmyard manure.

Reverting to Table II, it will be noticed that the pedigree strains compare very favourably in second harvest year yields with commercial strains, if the fescues be excepted.

By the third harvest year the bred strains of cocksfoot and timothy have outyielded the commercial strains very appreciably on the manured plots. Commercial timothy has by the third year been killed almost right out by rust. The seed yield of pedigree cocksfoot on the nitrogen plots increases from the first to the third harvest year, but timothy seed falls off in the third year. This reduction in timothy seed was influenced to a great extent by the prolonged drought of 1933, for timothy, maturing appreciably later than the other species, was subjected to a long period of dry weather.

By the third harvest year the yields of the fescues have fallen exceedingly low, and are quite uneconomic as seed crops. They would, however, very probably maintain their yields better on soils of higher fertility, meadow fescue in particular.

(*b*) *Aggregate Yields.*

The aggregate total yields of each strain for the years in which crops were harvested for seed are given in Table II as figures relative to the yields of commercial strains at 100. Five of the eight pedigree strains, with the help of nitrogen, yielded crops of seed as good as or better than those given by commercial strains similarly manured. The strain least productive of seed in relation to the commercial strain is the pasture rye-grass. It yields about two-thirds of the yield derived from its commercial counterpart, and that would seem at first sight to be a serious disability for a type of rye-grass which is likely to rank as one of the most valuable for British agriculture. When, however, it is considered that ordinary rye-grass seed commands a lower price than the seed of most grass species, the increase in the price per acre need not be very great with a seeding of a pasture rye-grass. Furthermore, the seed grower would have an altogether better pasture after the first crop of seed than that obtained after taking a seed crop from ordinary rye-grass. An indication of this will be given later in this paper.

The bred strains of meadow fescue and red fescue stand better in relation to the commercial strains than the pasture rye-grass in respect of seed yields, and the difference between the yield of the two strains of red fescue for the first two years is not very considerable.

(*c*) *Size of Seed.*

The relative sizes of the seeds within a species calculated from the average weight per thousand seed are given in Table II. It will be observed that the bred strains of pasture rye-grass, cocksfoot, timothy and meadow fescue have relatively smaller seeds than the commercial strains. Pedigree strains of red fescue, Italian rye-grass and the hay type of perennial rye-grass compare favourably in seed size with ordinary types.

(*d*) *Dates of Harvesting.*

The dates of harvesting relating to the various strains have been averaged for 1931 and 1932 seasons, and are shown in Table II.

All the strains of Italian rye-grass are intermediate between the hay types of perennial rye-grass and the pasture type of perennial rye-grass in their dates for harvesting. There is only about a week's difference between the Italian strains and the pasture rye-grass, and this means that a greater risk from cross pollination is involved when these are grown for seed near each

other than when the hay types and pasture types of rye-grass are grown at a similar distance from each other.

Of the bred strains, that of red fescue is the only one which matures earlier than its commercial counterpart. The commercial cocksfoot, timothy and meadow fescue ripen their seeds from seven to eleven days earlier than the bred strains.

When grass seeds are grown on a farm scale, the harvesting dates indicate that the harvests in average years require attention very conveniently between the hay and the corn crops.

(*e*) *The Effect of Nitrogen.*

Reference to Table II again will show that nitrogen has been the means of increasing the seed yields of the first four species. Its effect on cocksfoot appears most marked in the third harvest year, and least marked in the first harvest year. The summer of 1931 was relatively wet, and the 4 cwt. per acre applied in the spring for the first harvest year of cocksfoot was undoubtedly too heavy to exert the maximum effect. The evidence suggests that nitrogen produces a greater positive effect on the seed production of some species, such as cocksfoot and timothy, when the rainfall is relatively low, and the increment becomes relatively greater from the first to the third harvest.

One cwt. per acre of nitro-chalk applied in the spring to the second crop of seed of meadow fescue causes a distinct increase in seed yield, but insignificant increases occur when 2 cwt. are applied for the third crops. Evans and Calder (1) found that 2 cwt. of nitro-chalk applied to the first seed crop of meadow fescue grown on fertile land decreased the seed yield. Meadow fescue requires fertile land in a region of comparativly low rainfall in order to produce maximum crops of seed from a stand over a number of harvest years. When the soil is rich and the district subject to heavy precipitation severe lodging may occur with the liberal application of nitrogen, and poor yields are associated with lodging.

Red fescue can do with even lighter applications of nitrogen for seed production than meadow fescue; only occasionally are the yields increased by nitrogen, and then by quite small amounts. More often nitrogen in the form of nitro-chalk inhibits the production of seed in this species very considerably. The reaction of red fescue to nitrogen in this experiment confirms the findings of Evans and Calder (1) and of Nilsson-Leissner (2). Chmelař and Mikolášek (3) found that liquid farmyard manure applied in the autumn reduced the number of fertile tillers in red fescue, but the increase in seed yield varied from 18 to 133 per cent.

The percentage increase or decrease due to nitrogen shown in Table III has been calculated from average figures for all plots of each strain, and for all the crops, with or without the fertilizer.

Eight quadrats, each 1½ feet long, were taken from each plot in order (i) to measure the effect of nitrogen on tiller counts, and (ii) to make a comparison between pedigree and commercial strains in relation to tiller counts. The numbers of fertile and barren tillers relative to commercial strains are shown in Table III.

The percentage increases of seed yields for all the strains included in Table III are encouraging to the seed grower. The increases in the pasture type of pedigree rye-grass and pedigree cocksfoot are outstanding, and are significantly greater than in the other strains of the same species. In a previous experiment (1) a first crop of this pasture rye-grass produced 48 per cent. more yield of seed with the assistance of 3 cwt. of nitro-chalk, but in that instance there was a tendency for the nitrogen plots to lodge. Nitrogen in the same year (1930) caused 100 per cent increase in the yield of seed from a pasture hay type of pedigree cocksfoot.

There seems to be a tendency for nitrogen to increase the average size of seed, although there does not appar to be a close relationship between the increase in the size of seed and the increase in yield. The size of seed in pedigree cocksfoot is connected with a large increase in total yield, but although the yield of pasture rye-grass is increased by half, the average size of the seeds remains about the same. In this latter case the explanation is that numerous late heads are produced and their seeds tend to reduce the average weight per 1,000 seeds.

The viability of the seed is not influenced significantly by the fertilizer.

Some important points emerge from a consideration of the tiller counts. Firstly, there appears to be a correlation between the number of fertile tillers and yield of seed. Secondly, nitrogen has increased the barren tillers very considerably in all the strains except the pasture perennial rye-grass and the two strains of timothy, and these latter are of special interest in relation to seed production. In the pasture rye-grass nitrogen has stimulated the production of 5 per cent. more barren tillers, which is negligible compared with the 33 per cent. increase of fertile tillers. The implication here is that nitrogen has been efficacious in converting barren tillers into fertile ones.

The successful use of nitrogen is illustrated in an even more

TABLE III.

Showing (a) percentages of increase or decrease on the nitrogen plots as compared with controls; (b) relative numbers of fertile and barren tillers, with commercial strains at 100.

	Perennial rye-grass.			Italian rye-grass.		Cocksfoot.		Timothy.	
	Commercial	Pedigree hay.	Pedigree pasture.	Commercial	Pedigree	Commercial	Pedigree	Commercial	Pedigree hay.
Seed yield	+ 27	+ 26	+ 48	+ 36	− 31	+ 31	+ 80	+ 49	+ 47
Weight per 1000 seed	— 1	+ 11	+ 1	+ 2	+ 3	+ 7	+ 21	+ 4	+ 5
Germination per cent.	+ 2	+ 1	— 1	+ 9	0	0	0	0	0
Fertile tillers	+ 13	+ 10	+ 33	− 28	+ 27	+ 20	+ 52	+ 20	+ 47
Barren tillers	+221	+281	+ 5	−198	+ 57	+ 95	+ 92	— 43	— 29
Relative numbers:									
Fertile tillers — N	100	165	92	100	95	100	84	100	261
Fertile tillers + N	100	161	108	100	95	100	106	100	326
Barren tillers — N	100	956	10815	100	298	100	217	100	233
Barren tillers + N	100	1133	3533	100	157	100	213	100	291

striking manner by the figures for timothy, in both strains of which nitrogen has actually decreased the number of barren tillers. The aim of the seed producer then should be to apply appropriate quantities of nitrogen at the proper time, so as to convert as many barren tillers as possible, especially in leafy types of grasses, into fertile tillers. It is quite extraordinary to find that nitrogen hastens the flowering and maturity of timothy strains. The same phenomenon with regard to wheat has been reported by Stafford, *et al.* (4).

The analyses of tiller counts in Table III show that in the second harvest year of the rye-grass strains, and in the last two harvest years of the other two species, the numbers of fertile tillers with the assistance of nitrogen are higher even in the bred strains than in the commercial strains.

All the bred strains excel in leafiness as measured by the number of barren tillers, and the overwhelming superiority of the pasture rye-grass over the commercial strain is proof of its persistency even after taking a seed crop in the first year.

Table IV shows the analyses for the two fescue species, on similar lines to those for the other species in Table III.

TABLE IV.

Showing (a) percentage increase or decrease on the nitrogen plots as compared with controls; (b) relative numbers of tillers with commercial strains at 100.

	Meadow fescue.		*Red fescue.*	
	Commercial	*Pedigree*	*Commercial*	*Pedigree*
Seed yield	+ 15	+ 35	— 1	— 9
Fertile tillers ...	— 2	+ 20	0	— 5
Barren tillers	+ 37	+200	+ 4	+ 76
Weight per 1000 seed	— 3	— 6	+ 2	+ 4
Germination per cent.	— 2	— 1	— 2	— 2
Relative numbers:				
Fertile tillers — N	100	82	100	80
Fertile tillers + N	100	92	100	76
Barren tillers — N	100	153	100	98
Barren tillers + N	100	358	100	114

The average increase in seed yield shown in Table IV for the meadow fescue strains is relatively high for this species, and the magnitude of the increase is largely due to the effect of nitrogen in the second harvest year, when only 1 cwt. per acre of nitro-chalk was applied. The response of the pedigree strain both in regard to yield and tiller numbers is greater in the pedigree than in the commercial strain.

Both strains of red fescue react unfavourably to nitrogen in seed yield and in fertile tillers. It should be made clear here that nitrogen has proved of doubtful value for stimulating seminal reproduction in fescue species when applied in amounts of 2 cwt. per acre of nitro-chalk in the spring, but there remains the possibility that autumn applications, under an appropriate system of management, may give more positive results.

The percentage differences that occur through the use of nitrogen, with regard to weight per 1,000 seeds and germination, do not appear to be significant in fescue strains.

Commercial strains of the two fescue species are more prolific in fertile tiller production than the bred strains, and, conversely, the bred strains develop barren tillers more abundantly, especially when the crops are fertilized with nitrogen.

(*f*) *Winter-greenness and earliness.*

Observations of the plots made from autumn to spring established the fact that all the bred strains were definitely more winter-green than the commercial types.

The only commercial strains which appeared to begin spring growth earlier than pedigree strains of the same species were those of cocksfoot and meadow fescue. Pasture rye-grass was certainly later than the commercial type, but the latter showed no obvious advantage in this respect over the hay type of pedigree rye-grass.

The plots of pedigree timothy were outstanding in greenness during March and April, and began growth at least two weeks before ordinary timothy. This is a noteworthy characteristic in view of the fact that the crop is on the average eleven days later in ripening its seed than the commercial type. The aftermath was distinctly superior to that usually associated with timothy. A grass strain which provides a better distribution of "keep" over the growing period, together with a greater capacity for winter-greenness than types sown ordinarily at the present time, is one that should be welcomed by the stock farmer.

Conclusions.

The following conclusions are based on the results obtained from studies made on seed crops of pedigree grass strains in comparison with commercial strains. The data cover two harvest years for perennial and Italian rye-grasses, and three harvest years for cocksfoot, timothy, meadow fescue and red fescue.

(1) It is possible to breed strains of grasses superior to the ordinary strains in leaf production and still able to produce in

the course of two or more harvest years an aggregate yield of seed as large as or even larger than that of the commercial types.

(2) Strains of superlative leafiness, suited for pasture conditions, may yield at least two-thirds as much seed as ordinary strains, and the price of such seed need not be greatly in excess of that of the ordinary sorts.

(3) Commercial strains tend to produce heavier yields of seed than the bred strains in the first harvest year, while the latter show to better advantage in the second and third harvest years. The seed yields of the bred fescue strains fall away more rapidly than those of the commercial strains.

(4) The hay types of pedigree perennial and Italian rye-grasses mature as early as the standard strains, and pedigree red fescue is even earlier than the standard strain. There is evidence that the pasture rye-grass and the pedigree strains of cocksfoot, timothy and meadow fescue are definitely later in ripening than the commercial types.

(5) Applications of nitrogen in the spring increase the yield of seed significantly in all the strains of perennial rye-grass, Italian rye-grass, cocksfoot and timothy. The effect of nitrogen is intensified in a dry year, and in crops subsequent to the first harvest.

(6) Nitrogen applied in the spring has very limited application for increasing the seed yields of meadow fescue and of red fescue.

(7) The size of seed is correlated with yield of seed in the strain of pedigree cocksfoot. Leafy strains within a species may have as large seeds as the more stemmy strains, but extreme leafiness is correlated with smaller seeds.

(8) Nitro-chalk increases the production of fertile tillers, except in commercial meadow fescue and the two red fescue strains.

(9) The increase in number of barren tillers is found to be considerable with nitrogen manuring, except in pasture rye-grass and timothy strains where the fertilizer seems to have been efficacious in converting a larger number of barren tillers into seed producing tillers.

(10) Except in the fescues, the fertile tillers are not less abundant in the leafy strains than in the commercial strains after the first seed crop.

(11) The superior leafiness of the bred strains is indicated by the relatively greater number of barren tillers,

(12) Pedigree strains are more winter-green than commercial strains, and while in some species the latter are earlier in spring growth, in others the bred strains are definitely earlier.

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THE MANAGEMENT AND MANURING OF PASTURE PLANTS IN RELATION TO SOIL ESTABLISHMENT AND PRODUCTIVITY.

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The sowing of grass and clover seeds must always remain an integral part of grassland farming, both in connection with temporary leys and so-called permanent pastures which require periodical renovation in order to be maintained at a high standard of botanical composition. Studies connected with the management of stock on newly sown pastures are of particular interest, therefore, in relation to methods of establishment of long leys and permanent grass.

The Station has now accumulated a considerable body of evidence having a bearing upon soil establishment in herbage plants. The garden trials, together with the earlier experiments under field conditions, have already been reported upon (1), (2), (4), (5). It has been shown that the number of established plants which may be expected from the sowing of one hundred viable seeds varies widely in different species, and also in different strains within each species. More recently, work of a related character has been reported from America (3) and this points to the same general conclusion.

Under field conditions the figure for percentage establishment bears a fairly constant relationship to the size of seed as

determined by the grain weight.[1] The factors governing this relationship are still somewhat obscure, but seem to be connected with the size of endosperm. Depth of sowing has probably a considerable bearing in this connection. In normal farm practice, or under conditions designed to simulate this, harrows are used for covering the seeds. It would be extremely difficult in practice to cover these to an exactly uniform depth; it is probable therefore that, while some seeds become buried too deeply, others will be left on the surface. Seeds with large endosperm from which the seedlings can draw their nourishment will usually have a better chance of producing fully established plants than those with small endosperm. Seeds buried deeper than their optimum depth will use up an excessive proportion of food reserves to push the plumule to the soil surface, while seeds germinating on the surface will be largely under the influence of current weather conditions, which may be favourable or inclement. Not only this, but seeds lying on the surface will naturally be more easily accessible to the ravages of birds and field vermin.

The ability to become established rapidly is a desirable attribute in pasture plants. Their reactions to different methods of grazing and to changes in the environment, including changes in standards of soil fertility, form a subject of engrossing practical interest.

The Experiment (E. 155, Gorse Field).

The sowing was made on April 4th, 1933. The experimental block had been bare fallowed in 1932 following after a crop of oats in 1931. The present trial was designed to test the influence of management and manuring upon the soil establishment and the productivity of seeds mixtures. The present paper deals with observations made in the seeding year (1933) upon two seeds mixtures representing (A) pedigree and indigenous strains, and (B) their ordinary commercial counterparts. Details concerning these mixtures are given in Table I, which shows also the grain weight and the average number of laboratory viable seeds sown per square yard. The average figure for percentage establishment based on evidence collected from this experiment is added.

In Figure 1 (facing page 160) a general view of a portion of the experimental block is shown.

The layout of the plots was based on the Latin Square method. The seeds mixtures A and B were sown on two adjoining half acre blocks and a 5 x 5 Latin Square was superimposed

[1] The average weight per 1,000 seeds is recorded as the grain weight.

upon each. This provided 25 x 1/50th acre plots in five traverses of five, within each Latin Square, and allowed for five different

TABLE. I.

Details of the two seeds mixtures, E. 155, Gorse Field, sown 4/4/33.

Species.	*Station number.*	*Lb. per acre. R.V. = 100.* *Mixt. A. (pedigree).*	*Lb. per acre. R.V. = 100.* *Mixt. B. (commercial).*	*Grain wt. (wt. per 1000 seeds) grams.*	*Av. no. of viable seeds per sq. yard.*	*Average percentage establishment.**
Perennial rye-grass (pedigree)	S 23	8.31	—	1.77	439	54.2
Perennial rye-grass (commercial)	Ba 2326	—	9.20	2.07	415	71.3
Italian rye-grass (pedigree)	S 22	5.00	—	1.99	235	31.3
Italian rye-grass (commercial)	Bb 247	—	5.67	2.34	227	23.7
Cocksfoot (pedigree)	S 26	8.53	—	0.97	822	21.7
Cocksfoot (commercial)	Bc 1817	—	9.05	1.06	796	29.4
Timothy (pedigree)	S 51	7.48	—	0.37	1891	5.8
Timothy (commercial)	Bd 691	—	7.32	0.33	2074	7.5
Meadow foxtail (pedigree)	S 55	2.94	—	0.62	443	11.2
Meadow foxtail (commercial)	Bh 413	—	8.05	0.62	1210	8.0
Crested dogstail (commercial)	Bg 376	1.79	1.79	0.44	382	10.1
Rough-stalked meadow grass (commercial)	Bk 289	1.67	1.67	0.14	1116	5.3
Red clover (Mont.)	Aa 2045	2.46	—	1.80	128	63.4
Red clover (broad)	Aa 2059	—	2.57	2.09	115	42.0
White clover (Kent wild)	Ac 1234	2.59	—	0.55	440	31.2
White clover (Polish)	Ac 1233	—	2.73	0.62	412	28.1
Sheep's burnet	Ds 121	3.57	3.57	8.86	39	55.0

* From Table VIII.

treatments, each with five replications giving in all ten replicates of any particular treatment. Six of such replicates were grazed

on about a monthly basis, while the residual four replicates (two in each Latin Square) were grazed on a shorter rotation of 10-14 day intervals. The grazing was planned to be an elastic time schedule, so that the exigencies of growth in relation to weather and other conditions could at any time be taken into consideration. For example, because of the prolonged dry weather in 1933, the " monthly " grazed sections were in fact not stocked at all between the last week of August and the third week in October—a period of eight weeks.

All the grazing was by the Station flock of Kerry Hill ewes with their lambs. The procedure adopted was to fence each plot of 1/50th acre and at each grazing period to turn (usually) twelve sheep into each fold for a sufficient number of hours to graze it off cleanly. If the herbage became " staled " on any particular plot the sheep were moved on to the next one and were returned again in rotation until each set of plots had been evenly and closely grazed. Five sub-flocks each of twelve sheep were utilised for grazing. Careful records were kept of the time spent by the sheep on any given plot. A complete record was also kept of the number and class of sheep concerned, the whole being reduced to a common denominator on the basis of ewe hours per plot.[2]

The plan of the experiment was such as to allow for five independent sections each to be grazed for the first time during the season as follows : (1) at date of full brairding ; (2) one month later ; (3) two months after brairding ; (4) three months after brairding, and (5) four months after brairding. Within each section there were two sub-sections grazed (*a*) monthly, or on a " long rotation," and (*b*) fortnightly, or on a " short rotation." Of necessity, and as explained above, the grazing time-schedule was an elastic one. In a season of normal rainfall a full braird would have been obtained in about three weeks after sowing and Section 1 would then have been grazed over. Consequent, however, upon the dry spring and in particular the low rainfall of April and May, 1933, Section 1 was not grazed until May 31st—over eight weeks after sowing the seeds—the date coinciding with full brairding on the plots. In sympathy with this the dates of first grazing in the remaining four sections were also delayed, the respective dates being twelve, sixteen, twenty and twenty-four weeks after sowing. The appearance of the growth on June

[2] Since lambs with their mothers were used in the trial an arbitrary figure was adopted for the ratio of lambs to ewe equivalents. These ratios were as follows:—Up to end of May 6 lambs = 1 ewe ; June-July $2\frac{1}{2}$ to 3 lambs = 1 ewe ; August to October, 2 lambs = 1 ewe.

9th, namely, ten weeks after sowing, may be judged from a study of Figure 2 (facing page 160).

The following statement will show the date range during which the five different sections were grazed, the number of grazing periods and the total number of ewe hours per 1/50th acre plot in each section. It will be seen that sections 1 and 2 have had altogether more consolidation than the other sections as measured by the total ewe hours per plot. This factor is significant in connection with soil establishment, discussed later in this paper.

Section.	*Grazing dates, 1933.*	*Number of grazings.* When monthly.	When fortnightly	*Total ewe hours per 1/50th acre*	*Ewe hours. Relative.*
1.	31/5 (8 weeks after sowing to 31/10) ...	6	10	216	**100**
2.	29/6 (12 weeks after sowing to 31/10) ...	5	9	242	**112**
3.	24/7 (16 weeks after sowing to 31/10)	3	7	189	**87**
4.	21/8 (20 weeks after sowing to 31/10)	2	5	156	**72**
5.	18/9 (24 weeks after sowing to 31/10) ...	2	3	160	**74**

The relative number of ewe hours per plot is not meant to convey relative productiveness in terms of sheep carrying capacity. It cannot do so, since in sections 3, 4 and 5 there was a great deal of feed trodden under foot in the course of the first grazing thereon. Much of this was wasted. In the two latter sections in particular the fodder at the " first grazing " dates, namely, 21/8/33 and 18/9/33 respectively had grown to quite a hay crop. This was therefore scythed over and collected together to be fed back to the sheep on the plot from which it had been cut. The system proved efficacious in so far as the even grazing of the plots was concerned, but there remained a considerable proportion of long cut grass which the sheep rejected.

Manuring.

Each fold was divided transversely into three parts, and each part treated manurially as follows :—

(*a*) PN—basic slag at 5 cwt. per acre applied day of sowing seeds ; nitro-chalk at 2 cwt. per acre applied 15/5/33 after brairding had taken place.

(*b*) P—basic slag at 5 cwt. per acre as above.

(*c*) C—no manure.

Analytical Work.

Samples for botanical analysis were taken throughout the season. These were cut (with shears) to a height of 1 inch above ground level, fifteen samples being taken at each sampling date, using the square foot mesh. The samples were analysed into constituent sown species and weeds by the percentage productivity estimation method (7). They were then carefully air-dried and weighed.

In the autumn of 1933 accurate counts were made relative to the numbers of plants of the sown species which had become established on the plots. Fifteen readings, using the 6 in. x 6 in. mesh, were taken on each plot and the percentage establishment was calculated.[3]

Meteorological Conditions.

Table II gives a summary of the rainfall, sunshine and mid-temperature at Aberystwyth for each month of 1933. The total rainfall and total hours of sunshine occurring during the period April to September inclusive are also given. For comparison, the April to September figures for rainfall and sunshine for the years 1925-1933 are added. The weather conditions at Aberystwyth during 1933 were wholly abnormal, with exceptionally low rainfall in the summer months, high figures for sunshine, and temperatures well above the normal.

Discussion of Results.

A. Gross Yields.

Table III gives the yields of air-dry fodder in lb. per acre based on the pre-grazing samples. The commercial mixture, as is usual during the seeding year, has slightly outyielded the indigenous for the period under review. Comparing the relative yields, the low figure for section 3 is noteworthy, and is related to the adverse climatic conditions prevailing during the period which followed the date on which this section was grazed for the first time (24/7/33). The weather during that period was both dry and hot. Having regard to the adverse season, however, the relatively high figures for sections 1 and 2 are remarkable.

[3] The percentage establishment is the average number of individual plants in any species expressed as a percentage of the average number of viable seed of that species sown per unit of area.

TABLE II.

The general meteorological conditions at Aberystwyth (a) during 1933, together with (b) the April-September rainfall and sunshine totals for years 1925-33.

(a) 1933.

	January.	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*	*Total.*	*Total for period Apr.-Sept. inclusive.*
Rainfall (inches)	4.05	3.42	2.61	0.75	1.19	2.80	1.57	1.46	1.17	5.39	1.02	1.53	26.96	8.94
Sunshine (hours)	101.2	77.5	136.8	138.0	150.7	180.2	183.4	200.3	207.7	85.5	97.9	77.5	1606.7	1060.3
Mid-temperature (F°)	37.4	38.8	45.9	46.5	52.1	57.7	61.4	61.6	59.2	50.6	42.5	35.8	—	—

(b) 1925-1933.

Period April-September inclusive.	*1925*	*1926*	*1927*	*1928*	*1929*	*1930*	*1931*	*1932*	*1933*
Rainfall (inches)	19.00	18.63	27.75	20.20	16.94	20.06	22.72	16.97	8.94
Sunshine (hours)	1111.9	989.7	923.5	1058.5	1177.6	898.3	928.0	891.3	1060.3

Grazing was commenced on these more or less as soon as keep became available on the plots. The data indicate that pasture plants can adapt themselves to adverse conditions of weather and make good recovery when more favourable conditions are resumed. The yields in sections 4 and 5 are a good deal higher than in sections 1 and 2, taking the season as a whole, however. There has been an appreciable response to manures, the ratio for gross yields being PN : P : C as 165 : 134 : 100.

TABLE III.

Comparative yields of air-dry fodder in lb. per acre for seeding year; (a) influence of management upon the indigenous and commercial mixtures, and (b) influence of manures upon total yield, E. 155, Gorse Field, 1933.

(a) Influence of management.

	Section 1	*Section 2*	*Section 3*	*Section 4*	*Section 5*	*Average.*	*Relative.*
Mixture A (indigenous)	1253	1334	1232	2372	2055	1649	(100)
Mixture B (commercial)	1342	1594	1283	2746	1976	1788	(108)
Average	1297	1464	1258	2559	2016		
Relative	(100)	(113)	(97)	(197)	(155)		

(b) Influence of manures.

	PN	P	C
Average Mixtures A and B	2156	1748	1302
Relative (with C = 100)	(165)	(134)	(100)

(*B*) *Productivity of the Seeds Mixture Components.*

(1) *Influence of management upon end of season yields: Sections 1 to 5.* Table IV (*a*) shows in summary form the productivity of each sown species (on 20/10/33) in relation to the date on which the various sections were initially grazed. For the purpose of discussion the species have been grouped in this table as follows :—

Major contributing grasses : perennial rye-grass, Italian rye-grass and cocksfoot.

Other grasses plus sheep's burnet : timothy, dogstail, rough-stalked meadow grass, foxtail and burnet.

Clovers : red clover and white clover.

Weeds : unsown species.

Perennial rye-grass, Italian rye-grass and cocksfoot have contributed the bulk of the feed offering. It is of interest in this connection to note that there is a general tendency in these

grasses to an increase of yield when not grazed too soon after sowing. This is apparent in the figures for percentage productivity as well as in the actual weights of air-dry fodder. Among the other sown grasses there is no such general tendency; their total contribution for the period has in any case been too small to draw any useful conclusion therefrom. The clovers, and particularly white clover, show appreciable reduction in series 5

TABLE IV.

The influence of management upon productivity at end of season (cut 20/10/33); (a) yields in lb. per acre of air dry grass in sections 1—5; (b) percentage productivity on short rotation (10-14 days) compared with that on the long rotation series (28 + days), E. 155, Gorse Field, 1933.

(a) Yield air-dry grass.

Section.	*Date when 1st grazed 1933.*	*Aggregate yields on 20/10/33* **in lb. per acre.**				
		Major grasses.	*Other grasses.**	*Clovers.*	*Weeds.*	*Total.*
1	31/5	148	4	16	6	169
2	29/6	170	5	15	7	197
3	24/7	187	7	17	4	215
4	21/8	216	7	20	5	248
5	18/9	237	7	12	4	260

(b) Percentage productivity in relation to length of rest period.

Rotation.	*Percentage productivity.*					*Air-dry wt. in lb. per acre.*
	Perennial rye-grass.	*Italian rye-grass + cocksfoot*	*Other grasses.**	*Clovers.*	*Weeds.*	
"Monthly"	52.7	32.5	2.5	11.0	1.8	289†
"Fort-nightly"	61.8	24.3	3.2	4.1	3.6	147‡

* Includes sheep's burnet in very small amount.
† Representing 8 weeks' growth (period 18/8—20/10).
‡ Representing 16 days' growth (period 4/10—20/10).

(grazed for the first time 5½ months after sowing). This was to be expected, since white clover is intolerant of excessive shading.

It is recognised that top grasses, and in particular Italian rye-grass, will tend to depress the growth of slower developing species during the early phases of the ley. A considerable body of evidence relating to this problem has been accumulated. Most of

the experiments concerned have naturally been conducted in years of higher summer rainfall than occurred in 1933. It is interesting, therefore, to note that the top grasses have the same general tendency of aggressiveness in relation to their sward associates in a year of low rainfall, although the shading of one grass by another must have been considerably less severe than in a season of normal growth.

Percentage production in relation to the length of rest between consecutive grazings is summarised in Table IV (*b*). The average yields per acre (cut 20/10/33) are also given for each series. These data are useful in so far as they indicate that perennial rye-grass shows ability to withstand the more severe grazing, its percentage contribution, that is, its contribution in relation to that of the remaining species, being considerably higher in the frequently grazed series. On the other hand, Italian rye-grass and cocksfoot have suffered from being grazed too frequently. On plots grazed frequently the percentage of red clover has fallen in consequence from 7.5 to 1.6 per cent. There is no significant difference in the figures for white clover, although critical observation on the plots at this period rather suggested that white clover was spreading more rapidly on plots which were being grazed frequently. In the table the figures for white and red clovers are aggregated.

TABLE V.

The influence of manures upon the total yield of air-dry grass for the 1933 season (sown species and weeds), E. 155, Gorse Field, 1933.

Manurial Treatment.	*Perennial rye-grass.*	*Italian rye-grass.*	*Cocksfoot*	*Other grasses*	*Clovers.*	*Weeds.*	*Total.*
PN	228	176	53	40	16	147	660
P	164	123	37	24	19	166	583
C (unmanured)	115	80	37	14	30	95	371

(2) *Influence of artificial manures upon production.* The average yields summarised in Table V are in relation to the effect of phosphates used alone and in combination with nitrogen. Both basic slag and nitro-chalk have increased the yields of the grasses, this being especially marked in the rye-grasses. The highest yields for clover are on the unmanured plots. The appearance of the plots in this connection has occasioned considerable comment during the latter part of the growing season. The majority

of both our past and current trials at the Station show that phosphatic manures have a beneficial influence upon establishment and growth of clovers. The result obtained in the present experiment is, therefore, in direct conflict with the general trend of the evidence. There are two factors which probably have some bearing upon this result, namely (1) that the experimental area with which we are now concerned is one of high natural fertility, and (2) in consequence of the abnormally dry season the application of phosphatic manures may have hastened the germination of the clovers as it did that of the grasses, but when this was followed by prolonged dry weather the seedlings of clover hay have failed to survive. This latter phenomenon has been observed in two of our previous trials at the Station, both of which were conducted in seasons characterised by marked drought during the spring months (see Davies (2) and Western (6)). The present data give a true picture of the state of affairs on the plots at the end of the 1933 season, and are further corroborated by the plant establishment data which are discussed below (see Table IX).

Throughout the latter half of the season the clovers have been more plentiful on the unmanured plots, while the grasses have been denser and more productive on the top dressed plots. The sum of the critical observations made throughout the season

TABLE VI.

Yields of grass (air-dry) in lb. per acre from the end of season cut (20/10/33) comparing indigenous and commercial strains.

Species.	*Mixture A. Indigenous.*	*Mixture B. Commercial.*
Perennial rye-grass	120	186
Italian rye-grass	45	43
Cocksfoot	13	24
Timothy	3	2
Meadow foxtail	Trace	Trace
Crested dogstail	Trace	Trace
Rough-stalked meadow grass	2	2
Red clover	10	10
White clover	8	5
Burnet	1	1
Weeds	7	4
Total	209	227
Relative	(100)	(108)

indicated that the PN and P plots were always very similar to each other in general appearance and composition, whereas the C (unmanured) sections were always in sharp contrast to them. The C plots were less dense, providing in the aggregate less feed,

and containing altogether more clover than either the PN or the P plots. The evidence embodied in Table V confirms these observations.

(3) *Comparative yields of indigenous and commercial seeds mixtures at end of 1933 season.* The commercial mixture outyielded its indigenous counterpart in the ratio 108 : 100. This is in general confirmation of our past experience. Examining individual strains, pedigree Italian rye-grass slightly outyielded the commercial strain, while pedigree perennial rye-grass and cocksfoot gave lower yields than commercial. There were no significant differences in the clover yields. The data are given in Table VI (page 152).

(*C*) *Soil Establishment of Sown Species.*

(1) *Influence of grazing technique.* The percentage establishment figures embodied in Table VII indicate the influence of management upon establishment. These data are discussed hereunder.

Percentage establishment varies significantly in the different species, and there is a general correlation between this figure and grain weight (see Table I). This confirms investigations already reported upon from the Station (2). The figure given for Italian rye-grass in the present experiment, however, is much lower than would be expected from a consideration of the size of its seed or from the evidence of previous trials. This is probably closely connected with the fact that the plots were heavily grazed. The establishment data are based on end of season counts, and a critical study of the plots at this period showed that Italian rye-grass plants had died back in considerable numbers; these dead plants were not included among the counts upon which the data for percentage establishment are based. Italian rye-grass, together with perennial rye-grass, has contributed a very large proportion of the first season's grazing on these plots. Having regard to its power of rapid recovery after defoliation, as well as its biennial nature, Italian rye-grass will have been treated unduly harshly and particularly so in the course of a dry summer. On the whole, establishment has been good having regard to the season. The figures for most of the species compare quite favourably with those collected at the Station in relatively wet seasons during the past decade (see referencs (1), (2), (5), (6)).

The average establishment on plots grazed from the start (section 1) is rather higher than on those where a season's growth had accumulated prior to their initial grazings (sections 4

TABLE VII.

Percentage establishment in relation to management in the seeding year. E. 155, Gorse Field; analysed autumn 1933.

	Section 1.	*Section 2.*	*Section 3.*	*Section 4.*	*Section 5.*	*Average.*	*Grazed every 10-14 days.*	*Grazed approx. monthly.*
Date when first grazed.	*31/5/33.*	*29/6/33.*	*24/7/33.*	*21/8/33.*	*18/9/33.*			
Perennial rye-grass	65.5	71.0	60.2	56.9	59.4	62.6	61.4	61.8
Italian rye-grass	28.9	25.2	26.5	29.0	31.2	28.2	23.7	31.1
Cocksfoot	20.7	23.8	25.6	29.0	29.4	25.6	22.4	23.8
Timothy	5.4	6.2	7.1	6.9	7.5	6.6	8.9	6.4
Meadow foxtail	9.0	9.5	8.1	9.2	12.2	9.6	10.1	11.8
Dogstail	12.3	13.8	9.9	8.5	8.1	10.5	12.0	9.5
Rough-stalked meadow grass	4.5	5.1	4.7	5.8	6.5	5.3	5.5	5.3
Red clover	46.1	49.3	54.6	56.0	47.7	50.8	46.8	53.5
White clover	30.6	35.0	31.5	25.0	26.1	29.6	33.9	24.4
Burnet	52.7	58.5	53.4	66.3	47.8	54.7	49.7	55.9
Average of 7 grasses	20.9	22.0	20.8	20.8	22.0		20.6	21.4
Average of 2 clovers	38.4	42.2	43.1	40.5	36.9		40.4	39.0
Average of all species	27.6	29.2	28.2	29.3	27.6		27.4	28.4

and 5). In particular the figures for perennial rye-grass, dogstail and white clover are high in sections 1 and 2, and are better in the latter than in the former.

The data in Table VII (page 154) with reference to establishment on plots grazed on the short as opposed to the long rotation are instructive. On the average of all species the plots grazed frequently show the slightly lower figure. Examining the results in detail, however, it is found that of the grasses, perennial rye-grass, cocksfoot, timothy, meadow foxtail and rough-stalked meadow grass show little reaction to the differential treatment. The figures for Italian rye-grass, red clover and burnet have been appreciably lowered in the frequently-grazed series. White clover, and to a less marked extent dogstail also, show higher figures for percentage establishment on plots where the grazing was most severe. White clover and dogstail do best on a well-consolidated surface and where shading from other plants is the minimum (8).

Establishment in herbage plants is a reflection not only of the edaphic conditions in terms of inherent soil fertility but also of conditions set up by the grazing animal. The surface of the soil is consolidated by the hoof action of the animal; soil is pressed more firmly around the roots of the establishing plants; the fertility of the immediate surface layers of the soil is enhanced by the deposition of animal excreta both liquid and solid. The influence of the grazing animal during the early periods of establishment is therefore a beneficial one in so far as the soil surface is consolidated and enriched. On the debit side the animal, left to its own devices, will defoliate the young plants, will, therefore, tend to make them weaker and to lessen their power of rcovery. Experience shows too that seedlings may be partially, and even wholly, uprooted in considerable numbers by the action of both tooth and hoof in the process of grazing.

Close grazing allows light and air to reach the surface and the faster growing species, usually the least persistent, are not allowed to become aggressively competitive in the sward. It appears from the evidence that even in years of abnormally low rainfall, such as 1933, frequent and close grazing, if carried out judiciously, need not be unduly harmful to the permanent elements in the mixture. The greater consolidation of the soil and the addition of animal droppings may be highly beneficial, as is indicated by the figures for perennial rye-grass, dogstail and white clover in Table VII. This is of some importance in connection with the renovation and re-seeding of rough grazings and hill

pastures in Wales. It is not always possible to fence adequately areas so improved, with the result that they will usually be grazed excessively hard. It is important to know that perennial rye-grass, dogstail, and white clover will establish themselves even when the swards containing them are closely and frequently grazed in the seeding year, because appropriate strains of rye-grass and white clover in particular are fundamental ingredients of the simple mixture and are suitable over a wider range of habitat conditions than is commonly assumed.

TABLE VIII.

The percentage establishment of pedigree and indigenous seeds compared with commercial strains, E. 155, Gorse Field. Analysed in the autumn of 1933.

	Mixture A. Indigenous.	*Mixture B. Commercial.*
* Perennial rye-grass	54.2	71.3
* Italian rye-grass	31.3	28.7
* Cocksfoot	21.7	29.4
* Timothy	5.8	7.5
* Meadow foxtail	11.2	8.0
Dogstail	10.5	9.6
Rough-stalked meadow grass	7.0	3.6
Red clover	63.4	42.0
White clover	31.2	28.1
Burnet	50.9	59.1
Average of 5 grasses marked * ...	21.8	28.0

(2) *Comparative establishment, indigenous and commercial strains.* The figures are summarised in Table VIII. Considering the grasses individually, the data for establishment show similar trends to those found in productivity. Commercial perennial rye-grass has established itself better than the pedigree strain; the advantage is similarly with commercial cocksfoot as compared with pedigree. In Italian rye-grass and meadow foxtail the pedigree lots are slightly higher. In the red clovers, Montgomery red has established itself very much better than broad red;* likewise wild white clover has consistently given a higher figure than Polish white.

(3) *Influence of the manures upon establishment.* The data given in Table IX show that in this experiment manuring has had relatively little influence upon establishment in the grasses. Emphasis is again laid upon the fact that we are dealing with a relatively fertile soil which furthermore has been liberally

* The particular lot of broad red used in this experiment has shown an abnormally low figure for percentage establishment throughout the plots.

manured in past seasons during its normal rotation as an experimental block† On the average of all the grasses the percentage establishment is approximately the same on all plots, while the figures for perennial rye-grass and dogstail are highest on the unmanured sections. With reference to productivity in the grasses, there was an appreciable increase of yield due to manuring, but no such general trend is found in respect of establishment. In the clovers, on the other hand, both P and (still more so) PN have depressed establishment. These data are based on the averages of large numbers of plots (fifty for each manurial treatment) and are statistically significant. For red clover the average percentage establishment on PN, P, and C plots is 43.3, 50.8, and 59.2 respectively, the comparable figures in respect of white clover being 22.6, 28.6, and 37.7 per cent. These latter figures are wholly in accord with the field notes and general observations made upon the plots as well as with the yield data already discussed (Table V). The depression of percentage establishment at the end of the seeding year on plots receiving manurial dressings has been noted in previous years by Davies (2) and Western (6).

TABLE IX.

Percentage establishment in the sown species in relation to manurial treatment, E. 155, Gorse Field. Analysed in the autumn of 1933.

Species.	PN.	P	C
Perennial rye-grass	58.9	62.5	66.3
Italian rye-grass .	30.8	28.3	25.5
Cocksfoot	26.9	23.0	26.8
Timothy	8.1	7.4	4.5
Meadow foxtail	10.1	8.6	10.1
Dogstail	9.5	9.9	12.2
Rough-stalked meadow grass .	7.6	4.8	3.5
Red clover	43.3	50.8	59.2
White clover	22.6	28.6	37.7
Burnet	44.2	55.9	65.0
Average of 7 grasses	21.7	20.6	21.3
Average of 2 clovers	33.0	39.7	48.5
Average of all species	26.2	28.0	31.1

Summary and General Considerations.

The experiment reviewed in this article deals with the behaviour of grass and clover during the seeding year with particular reference to management and manuring. No nurse crop

† Between January, 1927, and November, 1931, the block received adequate dressings of farmyard manure, superphosphate, lime and shoddy.

was sown. Ewes and lambs were used throughout for the grazings; the plots were stocked heavily for short periods and then given periods of rest according to schedule. The following conclusions may be drawn from the evidence accumulated :

(1) Pastures can be successfully established under a system of judicious rotational grazing carried out in the seeding year even though the rest period between consecutive grazings is of short duration. Having regard to the abnormally dry season and the consequent slowness of recovery after grazing, the management proved to be very severe. The plots were grazed down very bare at each grazing period, yet the sown species have established themselves satisfactorily in the face of both severe grazing and adverse weather.

(2) Basic slag applied at sowing time and nitro-chalk applied five weeks later have not greatly affected final establishment in the grasses. The establishment of the clovers, however, has been depressed on the manured sections. Initial germination in the grasses was hastened by phosphates and nitrogen; this was most marked some six to nine weeks after sowing, and gave the impression at that time that the unmanured plots would fail (see Figure 2). These early distinctions became levelled out about three months after sowing. Manures have, on the average, increased actual yields in the grasses, but caused a decrease in the yield of clover.

(3) Commercial strains of the grasses have established rather better than pedigree strains, and for the period under review have also proved somewhat more productive. The differences, however, are only slight, with the exception of perennial rye-grass, in which commercial was appreciably the better established. In Italian rye-grass and meadow foxtail percentage establishment was higher in the pedigree strains. Both Montgomery red and wild white clovers established better and gave higher yields than broad red and Polish white respectively.

(4) The establishment data for the grasses and clovers under test are in general agreement with those obtained in previous trials at the Station. These data might be usefully employed in drawing up seeds mixture prescriptions. If the desired ratio of plants in the established sward be stated, the composition of the mixture can be calculated from a knowledge of the grain weight and the potential figure for percentage establishment. Consider, for example, the simple mixture of perennial rye-grass, dogstail, rough-stalked meadow grass and white clover, and suppose the ratio of plants desired in the ultimate sward to be 60 : 10 : 10 : 20

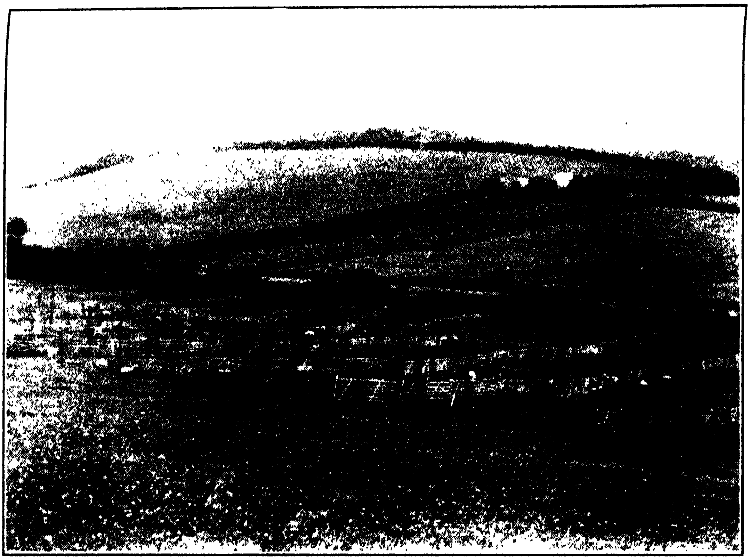

FIGURE 1.

General view of the experimental block to show lay-out of plots. E.155 Gorse Field. Photo. 24/7/33.

FIGURE 2.

View of portion of the experiment showing influence of phosphate (P); phosphate plus nitrogen (PN) and no manure (C). Photographed ten weeks after seeding; note also sparse growth generally due to the dry spring. E.155 Gorse Field. Photo. 9/6/33.

for these species in the order given above. If perennial rye-grass was (empirically) sown at 14 lb. of viable seed per acre, then, having regard to both potential establishment and grain weight, we should require to sow dogstail at 3.18 lb. per acre; rough-stalked meadow grass at 1.97 lb. per acre, and white clover at 3.04 lb. per acre, all adjusted to real value = 100. Assuming that Italian rye-grass and red clover be added as temporary elements, the mixture would read approximately as follows (lb. per acre, assuming real value = 100) :—

Perennial rye-grass	....	14 lb.
Dogstail	....	3 lb.
Rough-stalked meadow grass	....	2 lb.
White clover	....	3 lb.
Red clover	say	3—4 lb.
Italian rye-grass	say	3—6 lb.

Apart from the Italian rye-grass and red clover, which as temporary elements need not be considered in this discussion, the calculated ratio of established plants in the four remaining species would be 60 : 10 : 10 : 20. The sowing would give a total population of these four species representing some 3.5 million established plants per acre. This is equivalent to a total of eighty plants per square foot, namely, forty-eight plants of perennial rye-grass, eight plants of dogstail, eight plants of rough-stalked meadow grass and sixteen plants of white clover all per square foot. It is of interest to note that these seed rates of dogstail, rough-stalked meadow grass and white clover are higher than those usually advocated in seeds mixtures prescribed for permanent pasture. They approximate very closely, however, to the usual seed rates included in the ultra-simple seeds mixtures recommended by this Station. Simple mixtures of this type have furthermore given uniformly satisfactory results in practical trials extending over the past fifteen years.

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SOME OBSERVATIONS UPON THE RELATIVE PERFORMANCE OF COMMERCIAL AND OF INDIGENOUS FORMS OF SOME GRASS SPECIES UNDER GENERAL FARM PRACTICE.

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The following is an account of the relative persistency of commercial and of indigenous forms of some grass species under general farm conditions in some counties of North Wales. During the years 1928 and 1929 the mixtures set out below were sown in half-acre plots at a number of centres, covering a range of soil types, situations, and systems of farming practice.

TABLE I.

Seed per acre in lb.

Commercial.		*Indigenous.*	
Italian rye-grass	4	Italian rye-grass	4
Perennial rye-grass	15	Sutton's wild perennial rye-grass	17
Danish cocksfoot	7	Sutton's English cocksfoot	7
American timothy	6	Sutton's Scotch timothy ...	6
Rough-stalked meadow grass	1	Sutton's rough-stalked meadow grass	1
Broad red clover	8	Broad red clover	8
Late flowering red clover ...	2	Late flowering red clover	2
Kent wild white clover	½	Kent wild white clover	½

The clover elements were of the same origins for both plots.

TABLE II. Percentage composition of pastures in 1933. Average of twenty readings per plot.

County.	*Centre.*	*Year of Sowing.*	*Origin of Seed.*	*Perennial rye-grass.*	*Cocksfoot.*	*Timothy.*	*Rough-stalked meadow grass.*	*Wild white clover.*	*Yorkshire fog.*	*Bent grass.*	*Crested dogstail.*	*Sweet vernal.*	*Daisy.*	*Buttercup.*	*Red fescue.*	*Other unsown species.*	*Total unsown species.*
Anglesey	Llwynon, Llanfair P.G.	1929	Indigenous	29	16	3	11	**26**	8	0	2	1	2	1	0	1	15
			Commercial	11	6	1	7	39	15	2	5	1	2	3	3	2	36
	Pwllpillo, Rhoscolyn.	1928	Indigenous	37	3	1	10	**44**	T	0	1	0	2	1	0	1	5
			Commercial	11	T	2	9	52	4	0	7	0	4	2	0	9	26
	Ty'n Llan, Bodedern.	1928	Indigenous	27	4	5	10	38	1	T	3	0	6	1	0	5	16
			Commercial	15	1	2	7	45	5	1	6	0	5	3	0	10	30
	Brynhyfryd. Bryngwran.	1928	Indigenous	35	7	2	9	**17**	9	0	8	4	1	6	0	2	30
			Commercial	19	1	T	6	21	22	T	12	8	2	8	0	1	53
Flintshire	Tr'abbott F'wr Newmarket.	1929	Indigenous	10	36	6	6	**34**	0	0	0	0	6	T	2	0	8
			Commercial	6	10	3	3	52	3	0	T	0	14	2	6	1	26
	Ffyddion, Lloc.	1929	Indigenous	40	6	T	6	44	0	0	0	0	1	0	2	1	4
			Commercial	15	3	2	7	60	8	0	1	0	0	0	3	1	13
Denbighshire.	Llwyn celyn, Llanrhaiadr.	1928	Indigenous	23	16	27	10	24	0	0	T	0	0	T	0	0	T
			Commercial	13	12	23	10	39	0	0	T	0	0	T	0	3	3
	Average.		Indigenous	29	13	6	9	32	2	0	2	1	3	1	T	2	11
			Commercial	13	5	5	7	44	8	T	1	2	4	3	2	3	26

The mixtures were the same in both years but for the fact that in 1929 indigenous seed of rough-stalked meadow grass was

not available, and commercial seed of this species was used throughout in that year. In view of the percentage figures for germination for indigenous perennial rye-grass being below those of the seed of commercial origin in this species, the seeding of the former was in both years augmented so as to provide approximately the same number of viable seeds per acre for both forms.

It is as yet too early to attempt a critical review of the relative performance of the various forms; the observations here are regarded more as an interim record of the status of the various swards. Up to the present only some of the centres have been examined in detail; those that were grazed over the summer of 1933 were examined botanically in that year by the Estimated Productivity Method. (See Table II, page 161). Others that were in hay will be examined next season at a time of year comparable with the times of the analyses of 1933, *viz.*, late May and early June.

Llwynon, Llanfair P.G.

At this centre one crop of hay only has been taken since it was laid down. At the time of analysis (end of May) the field was but lightly grazed. Most of the species were running into flower, and tufts of cocksfoot were general throughout the sward. Compared to the average of all the centres, the takes of wild white clover and timothy are low, while those of cocksfoot and rough-stalked meadow grass are high. The unsown elements in the sward are high, especially on the plot sown with commercial seeds. Yorkshire fog is prevalent on both swards, and the incidence of other weed species is higher than the average elsewhere.

Pwllpillo, Rhoscolyn.

The plot sown with indigenous seeds here offers a striking contrast to the rest of the field. The soil is light, and the loss of hold of the plants of commercial origin is evident from the high incidence of pioneer species like crested dogstail, Yorkshire fog and annual meadow grass on this plot as compared to the other. The sward established from indigenous seed is mainly composed of perennial rye-grass, wild white clover and rough-stalked meadow grass. It is particularly weed free, and demonstrates clearly the superiority of seeds of indigenous strains on light land of this kind.

Tyn-Llan, Bodedern.

The plots here are situated on heavier land than at Rhoscolyn, and they are subject to mixed grazing, including calves

and sheep. Pigs and poultry also have the run of it. The sward established from indigenous seed has a very clean, healthy sole, and is very evenly grazed. Yorkshire fog, crested dogstail and annual meadow grass contribute a fourth of the plants on the commercial sown sward.

Brynhyfryd, Bryngwran.

The swards here were alike the poorest of the Anglesey series both on casual examination and in the light of botanical analyses. Growth on both plots was far forward in the first week of June and inadequately grazed, though the keep from the plot sown with indigenous seed proved more palatable to stock, and was thus the more heavily grazed. Wild white clover stood low in both plots, and the heavy incidence of unsown species indicated indifferent management. Almost a third of the growth on the plot sown with indigenous seed, and over half the growth on the other, consisted of unsown species, largely Yorkshire fog, dogstail, sweet vernal and buttercup.

Treabbott Fawr, Newmarket.

The plots here have been annually mown for hay until 1933, and the changed conditions from those ruling mostly at the other centres are reflected in the analyses. Perennial rye-grass has been suppressed on both plots, and cocksfoot has dominated the sward. Daisies and red fescue are prominent on the plot sown with seed of commercial origin. By the end of the second week in June grasses of all species on the commercial sown plot were flowering abundantly, contrasting strongly with the greenness and absence of flowering on the other plot.

Ffyddion, Lloc.

Here the plots appear to be very well managed. The grazing is governed very carefully. The supremacy of the sward sown with indigenous seed is evident from its being almost wholly composed of two species, perennial rye-grass and white clover, and from its freedom from weeds. Poverty resulting from a much lower take of rye-grass of commercial origin, as compared to that of the indigenous strain (15 per cent. against 40 per cent.) has been checked, and a superabundant development of white clover has occurred rather than an inordinate spread of weed species.

Llwyn celyn, Llanrhaiadr.

The result of taking hay frequently on the composition of the sward is demonstrated here also. In both plots the species

sown have persisted better, and their relative contribution to the sward is strikingly even. Timothy has persisted excellently, and is much more abundant on each of the plots than anywhere else in the series. The sward was surprisingly clean throughout and free from weed elements. Even in the plot sown with seed of commercial origin the percentage of miscellaneous plants present is negligible.

General Conclusions.

1. Detailed analysis of these swards has amply proved the marked supremacy of plants established from seeds of indigenous origin over plants from commercial seed both as regards persistency and lateness of flowering. Preference for the plant established from indigenous seed is obvious from the way the grazing animal checks this sward, even where stocking proves often enough inadequate.

2. The value of persistence in a sown species as a check upon the pioneering of weeds and unsown species is demonstrated by the figures; where four or five years after establishment, weeds on the swards established from indigenous seeds average a tenth of the sward, elsewhere they constitute over a quarter of the yield. The slacker the management factor the wider this difference.

3. Good management can obviously arrest weed establishment; it can also direct internal change in the botanical composition of the sward.

4. The lighter the soil the higher the value of seeds of indigenous origin on the scores of persistency and of acting as a check to unsown species.

5. Continued haying compared to grazing definitely governs the balance of sown species in the sward. Species like cocksfoot and timothy, whether the seed be commercial or indigenous in origin, are largely favoured by hay being taken off the swards. Haying generally proves to be less critical a factor in affecting persistency of sown species than summer grazing.

FURTHER OBSERVATIONS ON THE EFFECT OF VARIOUS MANURES ON THE HERBAGE OF MEADOW-LAND.

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A trial was commenced in 1924 at the Farm of the University College, Bangor, in order to test various systems of manuring meadow-land. Hay has been taken from the land every year since, the yields have been determined each season, and detailed botanical analyses of the herbage of the various swards have been made on two occasions, firstly in January and February of 1930, and secondly in late April of 1933.

Interim observations on the experiment as regards hay yields and condition and composition of the swards up to the spring of 1930 appeared in Vol VII, 1931, pp. 142-55 of this *Journal*, and the reader is referred thereto for details of layout and management, for no departure has been made since in the conduct of the trial. The scheme of manuring adopted appears in the tables inserted in the text. Plot 5, to which ground limestone is applied every third year, has been dressed on three occasions, in the winters of 1924-5, 1927-8, and 1930-1 respectively.

The botanical composition of the swards in 1933 was determined by the Estimated Productivity Method. For details of this method the reader is referred to pages 249-52 of *Agricultural Progress*, Vol X, 1933, in the symposium on Methods of Pasture Analysis.

Yield of Hay.

Table I shows the yields of hay for each of the years 1930, 1931, 1932 and 1933. Average yields for these years follow, and in the last column is added the average yield for each plot since the start of the trial.

1. *Farmyard manure.*

This plot receiving farmyard manure annually continues to give the highest average yield. Its supremacy is not sustained year by year as firmly as it was up to 1929, for though outstanding in 1930 and 1932, the yield from it has been exceeded from other plots, both in 1931 and in 1933. These results do not shake our belief in the efficacy of farmyard manure applied each

year for the production of hay, for the average annual increase per acre over the no-manure plots for all the years is 8 cwt., or 25 per cent.

TABLE I.

Yield of hay per acre.

	1930	1931	1932	1933	Average, 1930-33	Average, 1925-33
	Cwt. qr.	Cwt. qr.	Cwt. qr.	Cwt. qr.	Cwt. qr.	Cwt. qr.
1. Farmyard manure annually	46.0	25.2	36.1	30.2	34.2	35.0
2. †Farmyard manure and slag alternately	38.1	26.2	31.3	27.3	31.0	29.3
3. No manure	35.1	25.2	31.0	27.0	29.3	27.0
4. Slag alone annually	33.1	18.2	27.0	21.0	20.3	22.2
5. Complete artificials plus limestone (app. 1931) every third year	44.1	26.0	34.3	33.1	34.2	33.1
6. Complete artificials	43.2	28.0	35.2	36.3	36.0	32.3
7. Complete artificials minus potash	38.3	16.2	29.1	27.2	28.0	27.2
8. No manure	37.3	17.2	28.0	33.2	29.3	27.1
9. Complete artificials minus phosphorus	41.3	30.0	33.1	37.0	36.1	33.3
10. Complete artificials minus nitrogen	45.1	27.2	32.2	28.2	33.2	32.0

† Farmyard manure was applied for the 1931 and 1933 crops, and basic slag for the 1930 and 1932 crops.

2. *Basic Slag.*

The depressing effects caused by applying slag alone each year, noted earlier, are now considerably more marked than when first observed. While this plot yielded on the average 23 cwt. of hay per acre up to 1929, the average for 1930 to 1933 is depressed to 20 cwt. It would appear that the continued application of slag alone has a cumulative deleterious effect as compared with the two no-manure plots, each of which has yielded annually an average of 27 cwt. of hay per acre.

Further evidence of the depressing effect of slag on hay yield—evidence that is more convincing than that available in 1930—is shown by the results from plots 2 and 9, the plots receiving respectively farmyard manure and slag in alternate years,

and from the plot dressed with complete artificials but omitting phosphates each year.

The plot receiving farmyard manure and slag in alternate years is but little above the no-manure plots in yield. Reference to the table of yields shows how far short of plot 1 its yield fell in the years following the application of slag (1930 and 1932). The effect of omitting slag from a dressing of otherwise complete artificials is seen by comparing the figures for plots 6 and 9. Plot 9, receiving kainit and sulphate of ammonia, is second only to the plot receiving farmyard manure annually for the average of all the years, and for the second range of years (1930-3) it proves the best plot of any for yield of hay. For the same years plot 6, with complete artificials, is almost identical with it, though for the whole range of the experiment there is nothing to indicate that there is any advantage to be derived from the application of phosphates under the conditions ruling here and for the purpose of increasing hay yields.

3. Potash.

It will be recalled that this trial up to 1929 amply demonstrated the beneficial effect of the application of potash on yield of hay and seriously challenged our notions at the time in assuming that the application of potash was scarcely necessary for grass and hay on medium or heavy soils. Every year, over the course of the trial, the omission of potash from an otherwise complete blend of artificials has seriously depressed the yield. For the average of all the years, this omission has depressed hay yield by 5 cwt. per acre. Over the later period (1930-3) the figure stands at 8 cwt. per acre, and for one year (1931) it is of the magnitude of 12 cwt. It would seem that the longer the trial runs the more marked will the effect of the omission of potash be in its depressing effect on yield, as the continued application of slag appears cumulatively depressing in its effect.

It may add more significance to the figures if stated thus. The beneficial effect of applying farmyard manure as compared with applying no manure year by year is no greater than the effect of adding potash to an otherwise complete blend of artificials. The former is well established in general farming practice, and it would be well to see to it that, where artificial manures are periodically applied for hay, potash is not omitted as an element of the mixture.

4. Nitrogen.

It would appear that, as the life of the swards extends and

the annual applications are extended, there is more significance to be read into the figures for the omission of nitrogen from the blend of artificial manures used. In the years 1930-33 there is a margin of 3 cwt. of hay per acre in favour of not omitting nitrogen. Up to 1929 the figures indicated no significant difference in yield when this element was included as compared to the yield on the plot where it was omitted.

5. *Lime.*

More than hitherto there is nothing to indicate as far as yield is concerned that the application of ground limestone in the winter of 1930-1 to plot 5 has been beneficial. Since the inception of the trial, on three occasions this plot has received its tri-annual application of limestone, but with no apparent enhanced yield following.

Botanical Composition of the Herbage.

The swards were examined in detail in the spring (April) of 1933 after the plots had been down for nine years. The results are set out in Table II, and the species are set out in the same order as in the interim report on the composition of these swards. The method of analysis—the Estimated Productivity Method—employed was adopted in preference to the Percentage Productivity Method employed in the earlier analysis; the first mentioned is a more expeditious modification of the last mentioned, and the figures in this table and the earlier one are arrived at in the same way, and are thus comparable.

Some indication of the significance one can read into the figures can be found from the probable error figures that are given in each case for perennial rye-grass, for crested dogstail, and for wild white clover. These alone are included in the belief that inclusion of all species on all plots would confuse the table and detract from its clearness.

General.

This field conforms to the term meadow in that hay is taken off it each year, the aftermath is grazed by dairy cows, and sheep graze over it in winter well on into April. Usually it is not put up for hay until towards the end of that month.

The effect of this winter grazing is reflected in the general trend of the change in vegetation over the whole field as the years pass as much as in the specific effect of haying each season. Over the whole of the plots the cocksfoot element has shrunk considerably since 1930. On many plots but a fraction of a

TABLE II. Percentage Occurrence of Species.

	Perennial rye-grass.	*Cocksfoot.*	*Timothy.*	*Rough-stalked meadow grass.*	*Crested dogstail.*	*Wild white clover.*	*Yorkshire fog and soft brome*	*Bent grass.*	*Other miscellaneous species.*	*Total unsown species.*
1. **Farmyard manure annually**	31.5 ± 1.07	.6	10.5	14.1	5.3 ± .13	14.6 ± 1.20	8.3	—	12.1	20.4
2. **Farmyard** manure and basic **slag in alternate years**	34.9 ± 1.6	.6	8.9	9.2	6.0 ± .15	14.3 ± 1.6	12.5	—	13.6	26.1
3. No manure	26.8 ± .87	1.0	5.9	8.4	18.5 ± 1.31	9.2 ± .67	13.9	.2	16.1	30.2
4. Slag alone annually	33.2 ± 1.0	.5	5.8	7.3	10.1 ± .18	10.7 ± .87	11.5	—	20.9	32.4
5. Complete artificials annually with ground limestone every third year	36.1 ± 1.1	3.2	3.7	8.5	2.1 ± .11	20.0 ± 1.1	19.8	.5	5.8	26.1
6. Complete artificials annually	34.0 ± 1.11	.4	3.9	7.1	1.7 ± .10	26.6 ± .15	15.2	.4	10.7	26.3
7. Complete artificials minus potash annually	41.3 ± 1.74	.2	3.5	7.0	6.5 ± .14	5.5 ± .93	17.7	.2	18.1	36.0
8. No manure	21.8 ± .87	.3	3.6	4.9	17.6 ± 1.07	12.9 ± .15	16.2	.5	22.2	38.9
9. Complete artificials minus phosphate annually	33.0 ± .87	3.6	6.0	6.4	9.9 ± .09	16.2 ± 1.0	11.5	.3	13.1	24.9
10. **Complete artificials minus nitrogen annually**	28.5 ± 1.18	2.3	2.9	4.6	10.9 ± .18	21.0 ± .12	18.6	.3	10.9	29.8

percentage remains where formerly 6 or 7 per cent. or even a tenth of the sward consisted of this species. Timothy has stood the flux of time and circumstance more firmly. There is little significant difference in the percentage figure of its representation, excepting on plots 1 and 2, where it has doubled in the last four years, presumably through the continued addition of organic residues. Of perennial rye-grass it can be said that it has retained its hold well, though continued loss of fertility has materially depressed it on the no-manure plots as would be expected. Where mineral fertilisers alone have been applied, the enhancement of perennial rye-grass is in each case evident where nitrogen supplies have been added to the plots.

The figure for rough-stalked meadow grass seems to point towards a similar effect there too; outside the plots receiving organic manures the representation of this grass is materially lower than it was four seasons ago. The far less exacting species, crested dogstail, is in a different case. Its pioneering and colonising powers are shown by the way it has spread on the no-manure plots and on the last plot of the series.

The percentage of wild white clover in 1933 as compared to 1930 is down in all plots without exception. The fall is severe in those plots receiving farmyard manure either annually or in alternate years. It is least severe in the no-manure plots, but the continued lack of potash on plot 7 has by now served to depress it there to but a third of what it was four years ago and to but a twentieth of the whole sward.

It is gratifying to note that miscellaneous and unsown species of plants constitute a smaller percentage of the sward than they did in 1929-30. With the exception of plot 10, where they have been reduced by half, their representation in the spring of 1933 is plot by plot of the same order as at the time of the earlier analysis.

Significant changes in the representation of the major species as compared with the figures at the time of the earlier examination are referred to below.

Plot 1—Receiving slag alone annually.

Perennial rye-grass is holding its own as the major element. Cocksfoot has shrunk appreciably, and so has the white clover element. Against this there is a higher representation of timothy. The former superiority of this plot, as was noticed in the case of yield, is not as marked as it was in 1930.

Plot 2—Receiving farmyard manure and slag in alternate years.

As on the former analysis, there is no significant difference between the sward here and on plot 1 at any point. The change in percentage composition internally follows also the drift of the change in plot 1.

Plots 3 and 8—Control plots having received no manures throughout.

Floristically, these plots have not changed much meanwhile. The wild white clover figure still remains low; rye-grass retains its hold surprisingly well. Far less does their botanical composition reflect the loss from the non-application of manures to the crop than does the yield of hay from them as compared to the other plots for the reason already expressed in the earlier report on these swards.

Plot 4—Receiving slag alone annually.

The continued deleterious effect of this treatment, already noted on the score of yield, is only in part borne out by its botanical composition as recently determined. While it is true to say that the figures for rough-stalked meadow grass and wild white clover have been reduced by more than half what they amounted to at the time of the earlier analysis, it must be noted that perennial rye-grass has increased in the same proportion, and the figure for miscellaneous species, though still high, has improved within the last four years.

Plots 5 and 6—Receiving complete artificials each year with the addition of ground limestone to plot 5 every third year.

There is scarcely any ground for distinguishing between these two treatments on the score of the addition of limestone to the one. As previously stated, the soil, though devoid of calcium carbonate, contains lime in available form sufficient for sward growth and renders unnecessary, under the conditions ruling here, the added application of calcium carbonate. Compared to the plot receiving farmyard manure annually, these plots, though less excellent on the score of the figures for timothy and rough-stalked meadow-grass, surpass the former in their figure for wild white clover. They are also surprisingly free from miscellaneous weeds.

Plot 7—Receiving complete artificials minus potash annually.

Outside the excellence of perennial rye-grass—over 40 per cent., and the highest percentage recorded in this trial at any

time for any species—an excellence due probably to adequacy of nitrogen supplies, the marked feature of the vegetation of this plot is the way wild white clover has by now been suppressed almost completely. It has been lowest of all the series as regards this element from the start, and its contribution at present is almost negligible. It is the highest in non-gramineous weed elements. This fact, with the loss of wild white clover, largely accounts for its very low hay yield.

Plot 9—Receiving complete artificials annually minus phosphate.
The omission has in no way impaired the sward. The good early takes of cocksfoot and timothy have been depressed in later years less than they have been elsewhere, with the exception of plots 1 and 2, receiving organic manures. Perennial rye-grass stands much higher now than it did formerly, though the representation of wild white clover has shrunk more than elsewhere, and the plot is remarkably free from weeds and unsown plants.

Plot 10—Receiving complete artificials minus nitrogen each year.
The loss of nitrogen here as compared with plot 6, receiving complete artificials, is shown in the greater spread of crested dogstail and in a continued low figure for wild white clover.

Summary.

(A) On the basis of Yield.

1. The efficiency of farmyard manure applied each year for hay production has been clearly established. It continues to give higher returns than do any combinations of artificial manures tried. The average annual increase over the yield of plots receiving no manure for all the years of the trial is 8 cwt. per acre.

2. The depression of hay yield resulting from the yearly application of slag, shown earlier, has since become more marked. Neither is benefit derived from the addition of slag to plots already dressed with potash and nitrogen.

3. The deleterious effect of the omission of potash, already noted, becomes still more marked as the years pass. The benefits accruing from the use of potash are of the same order as those resulting from the use of a normal dressing of farmyard manure, comparing yields against yields from plots receiving no manure.

4. As the years pass there is evidence that the omission of nitrogen from the artificial manures supplied is reflected in loss of yield. This was not clear from the earlier years of the sward.

5. The plots continue to show no added return for the periodic application of ground limestone to land already in receipt of complete artificials.

(*B*) *On the basis of Botanical Composition of the sward.*

1. The representation of cocksfoot on all the swards has been considerably reduced. Timothy has withstood the conditions of the test more successfully, especially on the plots receiving organic manures. Perennial rye-grass holds the ground well, especially where high nitrogen fertility prevails; rough-stalked meadow grass less so outside the plots receiving farmyard manure. Crested dogstail proves its relative indifference to fertility by its spread on the plots receiving no manure; wild white clover has everywhere lost ground, on some plots severely so.

2. Though there have been internal changes in the representation of the better species within the plots receiving organic manures, botanically they remain superior, though this is less marked than in 1930.

3. Complete artificials would seem on the balance of species to rival closely farmyard manure as hay producers and to produce weed-free swards. The former treatment favours some excellent species, the latter others. The addition of limestone has had no appreciable effect on the swards as formerly.

4. The annual application of basic slag for hay proves by botanical analysis less deleterious than appeared at the time of the earlier analysis and than now appears on the score of yield. Rye-grass is gaining ground on the plot, which too is less foul with weeds than formerly.

5. The continued omission of potash has served to depress wild white clover almost to vanishing point, and considerably to increase the non-gramineous weed elements.

6. The omission of slag from an otherwise complete blend of artificial manures is reflected less in the composition of the sward than the omission of nitrogen and much less than the omission of potash.

THE EFFECT OF MANURES AT DIFFERENT ALTITUDES ON THE NITROGEN AND MINERAL CONTENT OF GRASS AND CLOVER SPECIES.

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The scarcity of grass during the lambing period is a source of serious loss to the upland farmer in Wales. At this time, which extends from the middle of March to the end of April, there is very little natural keep in these areas, and the absence of nutritious herbage so essential to the breeding ewes must cause a reduction in the output of lambs.

As might be expected, the botanical and chemical composition of the herbage varies from the lowlands to the uplands and this variation in composition will be appreciated from an examination of the data given in Table I. Here the percentage of nitrogen, phosphoric acid and lime in the dry matter of herbage taken at altitudes varying from 50 to 900 feet above sea level is shown.

TABLE I.

Sample Number	1	2	3	4	5
Nitrogen	3.47	2.90	2.42	1.98	1.57
Phosphoric Acid (P_2O_5)	0.94	0.76	0.59	0.41	0.26
Lime (CaO)	1.26	1.12	0.81	0.39	0.32

All the above samples were taken in the same season at the latter end of May and within four days of each other. Samples 1, 2 and 3 represent our first, second and third class pastures respectively, while sample 4 is typical of bent fescue and 5 of *Nardus* pastures. The variation in the nitrogen, phosphoric acid and lime content of these samples is very marked and shows a gradual decrease in these constituents from the lowland to the upland. Thus the dry matter of the herbage of sample No. 1 contains more than twice the nitrogen and about four times the phosphoric acid and lime that the *Nardus* pastures (sample No. 5) contains.

A botanical examination of samples 1, 2 and 3 showed that they contained roughly the same species but in varying amounts. Thus sample 1 contained about 30 per cent. perennial rye grass,

15 per cent. agrostis and wild white clover respectively together with about 10 per cent. each of crested dogstail, rough stalked meadow grass, fog and weeds. Sample 2 contained a lower percentage of perennial rye grass, rough stalked meadow grass and wild white clover than sample 1, but the percentage of fog and weeds was higher. Agrostis made the greatest contribution to the herbage of sample 3 of which it formed approximately 50 per cent. Fog and weeds together contributed some 35 per cent. and the remainder was represented by perennial rye grass, dogstail, rough stalked meadow grass and wild white clover. The herbage of sample 4 contained some 90 per cent. of Agrostis and fine leaved fescue, Agrostis if anything being the highest contributor. The remainder was made up of *Nardus* and weeds, no clover being present in the herbage. Sample 5 was largely composed of *Nardus* and *Molinia*. Agrostis and fine leaved fescue were also present, but only in negligible amounts. The botanical analysis of samples 1, 2 and 3 may be taken as typical of lowland pastures found in Mid-Wales, with representatives of 2 and 3 predominating. Pastures similar to sample 4 in botanical composition represent the intakes or *ffriddoedd* of upland districts while sample 5 may be taken as representative of a large area of the sheep walks in Wales. From what has been said, it will be realised that the nitrogen and mineral content of the dry matter of the herbage as shown in Table I is mainly influenced by the botanical composition of the areas. If, therefore, means could be found of improving the character of the herbage of the upland areas by promoting earlier growth and increasing its nutritive value this would prove of inestimable benefit to the upland farmer.

With this object in view, the following investigation was undertaken and experiments were conducted to ascertain (i) whether lowland grasses and clovers could be successfully grown at higher altitudes, and if so, whether their composition differed when so grown and (ii), whether these lowland grasses make earlier growth than those normally forming the herbage of these areas and by this means help to ameliorate the existing conditions.

A number of centres at which a previous investigation had been conducted in 1927 and 1928 were chosen for the purpose. These centres ranged in altitude from 50 to 900 feet above sea level.

At the termination of the 1927-1928 investigation four pedigree grasses and a clover, namely, perennial rye grass, cocksfoot, timothy, fine leaved red fescue and Montgomery red

clover, were grown at each centre, and the produce of the grasses cut at approximately monthly intervals was chemically examined.

In the 1927-1928 investigation, comparisons were made between sharply contrasting pasture types and their response to manures, the yield with the botanical and chemical composition of the samples taken from the pastures being determined. Three plots at each centre were used (1) control, (2) plot dressed with phosphates and potash and (3) a plot similarly treated to plot 2 but with the addition of periodic applications of nitrogen. The manures applied to these plots were superphosphate and kainit at the rate of 2 and 4 cwt. per acre, respectively. Plot 3 received, in addition, nitrogen in the form of Sulphate of Ammonia and Nitrate of Soda equal to 100 lb. of nitrogen per acre. The phosphate and potash formed the basal dressing applied in 1927, but the nitrogen was applied in 1927 and 1928 at the rate indicated above with this difference that in 1928 it was in the form of Nitro Chalk.

These original plots at the end of 1929 were dug up and a seed bed prepared upon them on which the grasses in the present investigation were sown at the rate of 15 viable seeds per linear inch. The grasses were sown in drills and before cutting for analysis were given a year to establish themselves, that is, from the date of sowing, May 22, 1930, to May 19, 1931, the first cut at all centres being taken at the latter date.

It is important to realise that manures were not applied to the plots in the present investigation until the second year, but for convenience of reference the plots are referred to under their previous designation, that is, control, phosphate and potash and phosphate, potash with nitrogen. Any effect this previous application of manure has on the mineral content of the herbage is, therefore, of a residual character, and will be considered before dealing with the results obtained when further dressings of manures were applied.

The "take" at the three upland centres, namely, Pensarn, Foel and Lletty, was extremely poor, especially on the plots that had served as control in the previous investigation. So poor were these, that early in 1930 it was realised that if certain drills at these centres were left in their patchy state there would be little material for chemical examination. To safeguard against this, soil from these plots was brought from the three centres and placed in boxes at the Station Farm, Frongoch. In these boxes, seed from the samples sown on the plots were sown at the same rate as on the plots and the resulting seedlings transplanted in

April, 1931, to fill up gaps in the drills on the plots as required.

As previously mentioned, the first sample for analysis was taken on May 19, 1931. The lowland centres, namely, Nantsiriol, Crosswood and Frongoch, ranging in altitude from 50 to 400 feet, looked extremely well, though the clover was not ready to cut at any of the centres. It is of interest to note that at this date of sampling, the influence of altitude on the growth made by the grasses was quite evident even within this comparatively narrow range. Thus fine leaved red fescue—the most advanced in growth of all the grasses—had its inflorescence fully emerged at Nantsiriol, making its appearance at Crosswood, while at Frongoch though the most stemmy of all the grasses it had no inflorescences. The same effect was shown by other grasses but not to the same extent as fine leaved red fescue.

At the lowland centres little difference was to be seen between the plots, though at Frongoch the plot which in the previous investigation acted as control was much poorer than the other two. This difference in appearance is also reflected in the chemical composition of the dry matter of the produce of the three perennial rye grass drills at this centre where the effect of the manurial residue on the mineral content of the produce is still evident.

TABLE II.

Shows the effect of the manurial residues on the mineral content of the dry matter of perennial rye-grass grown at Frongoch (400 feet above sea level).

Plot.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control	2.60	10.54	6.31	0.58
P + K	2.64	11.59	6.53	0.65
P + K + N	2.69	12.99	8.34	0.61

Plot.	*Lime* *CaO.*	*Potash* K_2O.	*Chlorine* *Cl.*
Control	0.76	2.14	1.14
P + K	0.92	2.48	1.35
P + K + N	0.98	3.10	1.77

The Table shows the effect of the manurial residues in the increased phosphate and potash content of the grass grown on the previously manured plot compared with the control. The

Table further shows the influence superphosphate has on the lime content of the produce and confirms results previously obtained (1).

A comparison of the lime content of the grass grown on the control plot with that grown on the plots to which superphosphate had been applied shows the latter to be some 80 per cent. richer in lime.

At the upland centres, namely, Pensarn, Foel and Lletty, the superiority in appearance of the plots benefiting from the residual effect of the manures stood in striking contrast to the unmanured plots. Fine leaved red fescue on all plots at these altitudes had made the most sturdy growth, cocksfoot was fair, but timothy on all the plots was poor and clover on the control plots was extremely poor. It should here be pointed out that seedlings of perennial rye grass, cocksfoot, timothy and clover had been transplanted to fill up gaps on the control and P + K plots at these centres. All the seedlings took, though they did not make very successful growth.

The influence of the manurial residues on the phosphoric acid and lime content of the grasses appears to be greater at these altitudes than on the lowlands. This effect is well illustrated in fine leaved red fescue grown at Pensarn, Table III.

TABLE III.
Pensarn (750 feet).

Plot.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control	1.55	5.48	3.80	0.42
P + K	1.68	6.28	4.52	0.45
P + K + N	1.63	8.53	5.95	0.58

Plot.	*Lime* *CaO.*	*Potash* K_2O.	*Chlorine* *Cl.*
Control	0.37	2.13	0.28
P + K	0.48	2.37	0.35
P + K + N	0.55	2.32	0.43

The influence of superphosphate on the lime content of the produce is quite pronounced, and it would appear from Tables II and III that its residual effect is equally persistent under both lowland and upland conditions. At both centres the lime content of the dry matter of the herbage from the plots which received

superphosphate is increased some 30 to 50 per cent. over that of the control. The effect of the previous application of the manures on the phosphoric acid and potash content though not so great is still evident. Thus, in the case of phosphoric acid it appears to be greater on the uplands than on the lowlands, whereas in the case of potash the position is reversed.

At the second sampling on June 19, 1931, the grasses on the lowland plots had made good growth and looked well but the clover was not ready to cut at any of the centres. A similar gradation in growth to that referred to at the first sampling was again to be seen on the lowland centres and the influence of the manurial residues was very obvious at Crosswood. Here the difference between the several manured plots was small, but between these and the control plot it was unmistakable.

Growth on the control plots at the upland centres was generally very poor, and the gradation in bulk of growth with altitude was more evident than on the lowland centres. The disparity in growth being so marked between the lowland and upland centres, it is of interest to compare the composition of the dry matter of the same grass at these two altitudes. For this purpose, cocksfoot grown at Nantsiriol and Foel has been chosen, and in Table IV its composition on the two control and manured plots at these centres is given.

The Table shows the dry matter of cocksfoot grown on the lowland control plot to be richer in phosphoric acid, potash and lime than that grown on the corresponding upland plot. However, a similar comparison of the composition of the dry matter of the herbage from the manured plots at the two centres indicates that although the herbage grown on the lowland plot is superior the difference between them is not as great as would be expected.

From what has been said of the difficulty experienced in growing some of the grasses at these altitudes the yield of dry matter from the upland plots compared with that from the lowland is, as would be expected, very much poorer, and especially is this the case on the control plots. The important point, however, is that, poor as the yield of the majority of the grasses is, the nitrogen, phosphoric acid and lime content of those that can be grown at these altitudes is much higher than that of the natural herbage (compare Table I sample 4 with Table IV). From these results it would appear that if a choice of grasses better suited to these altitudes is made, *e.g.*, fine-leaved red fescue and cocksfoot, these as shown in Table III and IV at

TABLE IV.

Nantsiriol (50 feet).
Lowland Centre.

Plot.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control	2.48	12.16	7.27	0.86
P + K	3.05	10.63	7.80	0.85

Plot.	*Lime* *CaO.*	*Potash* K_2O.	*Chlorine* *Cl.*
Control	0.60	2.78	1.50
P + K	0.60	2.89	1.10

Foel (850 feet).
Upland Centre.

Plot.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid.* P_2O_5
Control	3.04	9.01	7.28	0.56
P + K	3.10	9.33	7.38	0.72

Plot.	*Lime* *CaO.*	*Potash* K_2O.	*Chloride* *Cl.*
Control	0.45	2.57	0.85
P + K	0.51	3.21	0.92

certain periods of the growing season do not differ to the extent expected when grown on the lowlands and uplands. The results certainly give ground for inferring that a herbage could be produced at these altitudes which would provide food richer in those constituents in which the natural herbage is so deficient.

The first sample of clover was taken at all centres on July 21, 1931, when the grass drills were cut for the third time. The grasses at the lowland centres were in luxuriant growth and cocksfoot had made twice the growth of any other grass.

At the two previous dates of sampling attention was drawn to the gradation in bulk of growth with altitude, the order in the lowlands being Nantsiriol, Crosswood and Frongoch. On July

21, however, there was little difference between the first two centres though the bulk of growth at both was very much larger than at Frongoch.

The growth at the higher centres at this date was greater than at any previous sampling, but the clover was stunted in appearance, especially on the control plot at Pensarn, and the leaves on all the plots at Foel were yellow and looked anything but healthy. Here again the influence of altitude on the growth of clover was very marked, becoming gradually less in passing from Lletty through Foel to Pensarn.

TABLE V.

Control.

Centres.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Lowlands 50-400 ft.	3.52	10.36	9.26	0.74
Uplands 750-900 ft.	2.87	9.44	8.77	0.51

Centres.	*Lime* *CaO.*	*Potash* K_2O.	*Chloride* *Cl.*
Lowlands 50-400 ft.	3.05	2.15	0.50
Uplands 750-900 ft.	2.39	1.98	0.41

Manured.

Centres.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Lowlands 50-400 ft.	3.63	9.72	9.20	0.79
Uplands 750-900 ft.	3.05	9.10	8.64	0.60

Centres.	*Lime* *CaO.*	*Potash* K_2O.	*Chlorine* *Cl.*
Lowlands 50-400 ft.	3.36	2.26	0.52
Uplands 750-900 ft.	2.53	2.12	0.48

This being the first occasion on which a clover sample was taken it is of interest to compare the nitrogen and mineral content of the clover grown on the uplands with that of the lowlands. In Table V the average percentage composition of the dry matter of the clover from the three lowland and upland centres grown on the control and manured plots is given.

The composition of the clover grown on the control and previously manured plots of the lowland centres is richer in all the constituents determined than that grown on the corresponding plots of the uplands. It is surprising, however, to find how well the clover grown on the upland plots compare with those of the lowlands when the natural state of fertility of the two areas are taken into consideration.

Though four years have elapsed since the application of the manures, their effect is still to be seen on both areas, but appears to be more persistent and marked on the uplands. White clover would, of course, have been better suited to the conditions on the uplands than the red clover actually employed. The reason for the choice was that it is almost invariably used in seed mixtures with cocksfoot, rye grass and timothy being like these grasses among the " top " species in a ley.

From these results it may be concluded as in the case of the grasses, that where clover can be grown its contribution to the nitrogen and the mineral content of the herbage would be invaluable at these altitudes, particularly in the case of lime.[1]

An interval of two months was allowed to pass before the fourth sample was taken on September 28, 1931. The growth of the grasses at the lowland centres, Crosswood and Frongoch, was mainly leaf and on the whole looked well in spite of the fact that all species were slightly yellow in appearance and had their leaf tips burnt. The clover at Frongoch was very poor but the grasses at this centre were greener than at any other.

On the upland centres fine leaved red fescue was the only grass to keep its green colour, the remainder were yellow in colour and had their leaf tips burnt.

Throughout the season it was noticed that the residual effect of the manurial dressings, especially the P. K. N. plots, was very evident at all the centres but more particularly on the uplands. To illustrate this the composition of one and the same grass grown on the control and manured plots at a lowland and upland

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[1] In this connection it is important to realise that wild white clover has, in fact, been successfully established at a number of the centres where hill improvement experiments are in progress.

centre is given in Table VI. Timothy, a grass that has done poorer than any other under upland conditions, has been taken for the purpose. Table VI gives the composition of the dry matter of timothy grown on the control and manured plots at a lowland and upland centre sampled on the 28th of September, 1931.

TABLE VI.
Crosswood (300 feet).

Plot.	*Nitrogen N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control	2.84	7.18	5.01	0.75
P + K + N	2.88	7.52	4.64	0.79

Plot.	*Lime CaO.*	*Potash* K_2O.	*Chlorine Cl.*
Control	0.91	1.65	0.78
P + K + N	1.02	1.85	0.89

Pensarn (750 feet).
Upland.

Plot.	*Nitrogen N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control	2.20	6.80	5.10	0.44
P + K + N	2.36	6.69	5.14	0.59

Plot.	*Lime CaO.*	*Potash* K_2O.	*Chlorine Cl.*
Control	0.57	2.11	0.65
P + K + N	0.78	2.38	0.70

The dry matter of timothy from the control and manured plots is seen to be richer in nitrogen and all other mineral constituents with the exception of potash when grown on the lowlands compared with the uplands. With regard to the potash content of the grasses, it has been noticed throughout the season that in all the samples taken there has not been the difference in potash content between the same grass grown on the lowlands

and uplands that is met with when their phosphoric acid and lime content are compared. This is most probably due to the fact that the large majority of our soils, with the exception of those along the coastal belt, are generally well supplied with available potash. Again the residual effect of the manure, as was the case with clover, appears from the above Table to be more persistent and pronounced on the uplands than on the lowlands. Though, as previously mentioned, timothy is a grass that has consistently made poor growth on the uplands and appears to be quite unsuited for these altitudes, it supplies, where it can grow, a herbage much richer in phosphoric acid and lime than the natural herbage.

In the second season of the investigation it was thought that additional information might be obtained if similar manures were applied to those plots that were manured in 1927. Accordingly, on the 6th of April, 1932, dressings of superphosphate, kainit and sulphate of ammonia were applied to the appropriate plots in equivalent quantities to those applied in 1927. The nitrogen was applied in small doses in the form of sulphate of ammonia, the sum of these making a total equivalent to 100 lb. of nitrogen per acre.

The first sample in 1932 was taken on the 13th of June for the sampling was purposely delayed in order that sufficient material from the upland centres was available for chemical analysis. In the previous year it was found that while the system of sampling adopted suited the lowland centres admirably it was too short for the upland centres. At this date the lowland centres looked extremely well. The growth, however, was too mature to represent pasture, and but for its leafy appearance more closely resembled hay.

On the uplands the growth, in spite of the delay in cutting, was disappointingly poor on the control plots. At Pensarn and Foel, rye grasses, cocksfoot and fescue were in flower, but at Lletty the inflorescences of these grasses were only just emerging while timothy was still mainly composed of leaf. At the latter centre where the conditions were the most severe cocksfoot and fine leaved red fescue had done fairly well, but rye grass and timothy even on those plots receiving a complete manure were poor.

The difference in stage of maturity of the grasses on the lowland and upland centres at this date—the first date of sampling—had a considerable influence on the chemical composition of one and the same grass. This is illustrated in Table VII,

where the composition of cocksfoot grown on the lowland and upland is given.

TABLE VII.

Centres.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Lowland	1.68	6.56	5.14	0.43
Upland	1.80	6.16	5.22	0.46

Centres.	*Lime* *CaO.*	*Potash* K_2O.	*Chlorine* *Cl.*
Lowland	0.71	2.06	0.78
Upland	0.50	1.68	0.85

The lowland and upland centres from which the above samples were taken were Frongoch and Foel respectively, Frongoch being 400 feet and Foel 850 feet above sea level. The first point that strikes one on comparing the chemical composition of the two samples is their close similarity and this, to a large extent if not wholly, is to be accounted for by their difference in maturity. The growth on the lowland centres has passed its best and is showing general signs of deterioration, namely, a fall in nitrogen, phosphoric acid and potash and an increase in lime, whereas the growth on the upland centres is less mature with the result that they closely resemble each other in the majority of the constituents determined.

The second sample was taken on the 15th of August, 1982, when the grasses and clover on all the lowland centres looked extremely well and had made excellent growth. On the upland centres fine leaved red fescue and cocksfoot were the only productive grasses and this applied only to the latter grass on the plots receiving a complete manurial dressing. The growth made by rye grass, timothy and clover at all the upland centres was very poor.

It may now be definitely said that of the grasses made use of in this investigation, fine leaved red fescue and cocksfoot are the only two that appear to be suited to these upland conditions, and, as already stated, it is only when the land has been previously manured that the latter grass makes satisfactory growth.

The effect of the application of the manures applied on the

6th of April, 1932, on the mineral content of the grasses is shown in the case of fine leaved red fescue in Table VIII.

TABLE VIII.

Average percentage of nitrogen and mineral constituent in the dry matter of fine leaved red fescue grown on the control and manured plots in seasons 1931 and 1932 on the lowland and upland centres.
Crosswood (300 feet).
Lowland Centre).

Season and Plot.	*Nitrogen N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control 1931	2.12	8.61	4.29	0.61
Manured 1931	2.66	10.46	4.78	0.74
Control 1932	1.96	7.89	4.81	0.59
Manured 1932	2.47	8.59	5.82	0.75

Season and Plot.	*Lime CaO.*	*Potash* K_2O.	*Chlorine Cl.*
Control 1931	0.67	2.00	0.66
Manured 1931	0.77	1.98	0.67
Control 1932	0.63	1.65	0.49
Manured 1932	0.75	2.01	0.61

(Foel 850 feet).
Upland Centre.

Season and Plot.	*Nitrogen N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control 1931	2.43	7.35	4.38	0.44
Manured 1931	2.58	7.68	4.48	0.65
Control 1932	1.73	6.11	3.69	0.44
Manured 1932	1.86	6.78	4.21	0.76

Season and Plot.	*Lime CaO.*	*Potash* K_2O.	*Chlorine Cl.*
Control 1931	0.59	1.66	0.39
Manured 1931	0.78	1.68	0.46
Control 1932	0.56	1.68	0.39
Manured 1932	0.78	1.64	0.66

It should be remembered in any comparison made of the composition of grasses on the control and manured plots of the

lowland and uplands in 1981 that the manure was applied to these plots in 1927, and, as the Table shows, its effect is still to be seen on the lowland and uplands.

An examination of the Table shows the effect of the manure applied in 1982 to be practically negligible on the lowlands, and on the uplands it only appears to have affected the phosphoric acid content of the herbage. The Table brings out one interesting point, namely, the close similarity in composition of the grass grown on the lowland and upland on those plots to which manure was applied in 1982. This confirms a statement previously made that where a grass is capable of making reasonable growth there is little difference in the mineral content of the same grass grown on the lowland and uplands when the latter areas are manured. When in addition, as in the case of the grass under consideration it is fairly adapted to high lying areas, then the difference between them to all intents and purposes disappears.

The last sample of the season was taken on the 18th of October, 1932, when one of the most striking features in the appearance of the lowland centres was the poverty of the clover on all the control plots. It was hardly worth cutting at Nantsiriol, poor at Frongoch and had absolutely failed at Crosswoood. The grasses, however, especially on the completely manured plots looked well and the luxuriant growth of cocksfoot at Nantsiriol made the remainder of the drills look comparatively poor.

On the upland centres fine leaved red fescue and cocksfoot were by far the most vigorous and the colour of the former grass was greener than any other. Timothy and rye grass at these altitudes were poor and the clover was extremely poor. At all upland centres at this date the greenest herbage was on the completely manured plots where the herbage was mainly leaf.

In the following Table the nitrogen and mineral content of Cocksfoot on the control and manured plots of a lowland and upland centre at this date are shown for comparison.

It should be mentioned that at the date of sampling the Nantsiriol plots were among the best of the lowland centres while those of Foel may be taken to represent the average of the upland plots. When the phosphoric acid and lime content of the grass grown on the control and manured plots at the two centres are compared, it is seen that there is not that close similarity in composition found in fine leaved red fescue (See Table VIII) but that cocksfoot grown on the lowland is richer in both these constituents than that grown on the uplands. The reason for this is probably that already mentioned, namely, that fine leaved fescue is better suited

to these altitudes. However, the important fact is that the composition of the cocksfoot grown on the uplands is much superior

TABLE IX.
Nantsiriol (50 feet).
Lowland.

Plot.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control	2.07	9.40	5.82	0.84
P + K + N	1.88	10.24	5.71	0.89

Plots.	*Lime* *CaO.*	*Potash* K_2O.	*Chloride* *Cl.*
Control	0.81	1.61	0.88
P + K + N	0.95	1.76	1.20

Foel (850 feet).
Upland.

Plots.	*Nitrogen* *N.*	*Ash.*	*Silica free ash.*	*Phosphoric Acid* P_2O_5
Control	1.83	7.71	5.42	0.55
P + K + N	1.82	8.11	5.99	0.68

Plots.	*Lime* *CaO.*	*Potash* K_2O.	*Chloride* *Cl.*
Control	0.66	1.54	0.77
P + K + N	0.78	1.82	0.89

to the natural herbage growing at these altitudes as will be seen on comparing Table IX with Table I sample 4.

Conclusions.

In the present investigation it has to be remembered that the grasses were grown in drills and while this might be an advantage on the lowlands there is evidence for thinking that the grasses grown in this manner on the hills were exposed to more severe conditions than they would have been if grown in a compact pasture.

Of the grasses in the present investigation fine leaved red fescue and cocksfoot were the only two that made successful growth on the hill centres, and of these the former appeared better suited to these conditions.

The fact that fescue and, to a lesser extent, cocksfoot grown on the manured plots of the uplands compared favourably in their nitrogen and mineral content with the same grasses grown on the corresponding lowland plots is of the greatest importance. It indicates that if suitable species and, moreover, suitable strains of those species are chosen these upland areas are capable of considerable improvement.

Although timothy, rye grass and Montgomery red clover never made successful growth on the hills, where they did grow their nitrogen and mineral content was very definitely superior to that of the natural herbage of these altitudes.

It is only on those areas of the uplands that have received a complete dressing of manures that the introduced grasses can compare in nitrogen and mineral content with the same grass grown on the lowlands. and even then their yield on the upland is much smaller than on the lowland.

The effect of the manures, as would be expected, is more pronounced on the composition of the grasses grown on the uplands than of those grown on the lowlands, and the residual effect of the manures also appears to be more marked and pronounced on the uplands.

Though no lime as such was applied to the plots the effect of superphosphate in increasing this constituent of the herbage both on the lowlands and uplands is quite definite, and its effect in this direction is greater on the uplands.

It has to be remembered in reading the results obtained on the control plots that these plots served as controls in the previous investigation, and were consequently depleted of a considerable amount of plant food. For this reason they do not give a true picture of the state of fertility of the soils, but serve for purposes of comparison.

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THE RECOVERY OF NITROGEN IN PASTURES FROM THE APPLICATION OF NITROGENOUS MANURES.

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PART III.—The Recovery of Nitrogen in Swards under the Warmbold System.

In a number of earlier contributions the effect of nitrogenous manures on the protein yield from herbage plants has been discussed. It has been shown that the increment of protein which a farmer can derive from his pasture for milk production or live weight increase as a result of applying the same weight of nitrogenous manures varies within wide limits. Some of the factors have already been considered which account for the fact that one field may give a large increase of nitrogen as a result of manuring, while another may only return a small increment (1), (2). In the present article it is proposed to review some new data obtained from a number of experimental plots at the College Farm, Nantcellan, Aberystwyth. These plots were formed by enclosing a small area in one of the paddocks of the Rotational Grazing Field. Previous to its enclosure this area like the remainder of the field had been periodically manured and rotationally grazed by the dairy herd and its followers. The actual system of manuring and grazing has been described in detail in a previous issue of the Journal (3). One reason for the significance of the plots under consideration is that the herbage had already been intensively grazed over a period of three years prior to their enclosure.

In February, 1930, the enclosed area was divided into four 1/80 acre plots, A, B, C, D. The plots were manured and cut at monthly intervals during season 1930, and the data for this particular season have already been dealt with (4). In 1930 the whole plot received nitrogenous manures. In 1931, each plot was halved, one half receiving no further nitrogenous manures, while the other half received two instalments during the year. Apart from this difference in nitrogenous manuring the two halves of each plot were identically treated being given the same basal dressing of phosphatic manure, and the whole plot cut on the same day. Cuttings were taken from the plots in weekly rotation so that the same plot was cut at monthly intervals. The plots differed amongst themselves in that they were cut at

different dates, and the manures were not always applied at the same time. The total amount and the nature of the nitrogenous manures were, however, identical for all four plots. Table I indicates the yield of dry matter derived from the two portions of each plot during 1931 and 1932.

TABLE I.

The Effect of Nitrogenous Manuring on the yield of Dry Matter from the Total Cuts of each Plot. (Yield in lb. per 1/160 acre).

Season.	*Treatment.*	*Plot A.*	*Plot B.*	*Plot C.*	*Plot D.*	*Mean.*
1931	No Nitrogen	34.30	33.71	38.23	38.38	36.16
	Nitrogen	42.78	43.18	43.00	45.53	43.62
	Gain in Dry Matter Yield due to Nitrogenous Manure	7.48	9.47	5.23	7.15	7.46
1932	No Nitrogen	29.34	25.25	20.55	21.41	24.14
	Nitrogen	35.28	34.67	29.82	30.79	32.64
	Gain in Dry Matter Yield due to Nitrogenous Manure	5.94	9.42	9.27	9.38	8.50

It is seen from the above Table that a considerably higher yield was obtained from both treated and untreated areas during 1931 than 1932. This undoubtedly is largely due to the difference in climatic conditions between the two seasons, the rainfall during the period February-August, 1931, amounting to 24.64in., while over the same interval of time in 1932 it only amounted to 16.64in. On comparing those areas receiving nitrogenous manures with those control areas to which no nitrogen was applied, it will be seen that the diminution in yield as a result of the restricted water supply was less in the case of the nitrogen treated areas. Thus while the decrease in the dry matter yield from 1931 to 1932 in the control areas amounted to 33 per cent., the decrease in the case of the nitrogen treated areas amounted to 25 per cent.

Associated with the diminution in yield of dry matter is an increase in the percentage dry matter of the herbage. This is brought out in Table II.

Table II shows that the herbage during 1932 contained considerably more dry matter than that obtained during 1931. Further, it shows that the nitrogen treated herbage was generally

lower in dry matter content than the herbage from the control plots.

TABLE II.

Giving the yield of green and dry grass from the Plots during 1931 and 1932.

	1931. No Nitrogen.	*1931.* Nitrogen	*1932.* No Nitrogen.	*1932.* Nitrogen
Plot A.				
Green Weight	188	284	127	174
Dry Weight	34.3	42.78	30.34	35.28
% Dry Matter	18.25	18.28	23.89	20.30
Plot B.				
Green Weight	180	244	126	193
Dry Weight	33.81	43.18	25.25	34.67
% Dry Matter	18.80	17.70	20.00	18.00
Plot C.				
Green Weight	204	253	96	153
Dry Weight	38.28	43.00	20.55	29.00
% Dry Matter	18.74	17.00	21.40	19.00
Plot D.				
Green Weight	231	286	105	157
Dry Weight	39.38	45.53	21.41	30.79
% Dry Matter	17.05	15.90	20.40	19.60

The nature and amount of the nitrogenous manures applied during the two seasons was the same, *viz.*, 1lb. nitro chalk and 1lb. sulphate of ammonia per 1/160 acre. The nitro chalk was applied in both seasons during March. In 1931 the sulphate of ammonia was applied immediately after the 1st cut, *i.e.*, it was applied between the beginning and middle of May. In 1932 the sulphate of ammonia was applied from the middle to the end of June. As a result of this a marked difference is evident in the way the increase in yield of dry matter is distributed over the two seasons. This is evident from Table III.

During 1931 an increase of 1,003 lb. per acre out of a nett increase of 1,196 lb. was obtained before the end of June. In 1932 on the other hand only an increase of 428 lb. was obtained during this part of the season out of a total season's gain of 1,287 lb. The table clearly shows the effect of nitro chalk on the dry matter yield of the first cut in both seasons. It also shows that the sulphate of ammonia applied from April 29—May 19 in 1931 had a marked effect on the yield of the second cut taken a month after this manure was applied. Owing to the later application of the sulphate of ammonia in 1932, there was no

increased yield of dry matter in the second cut from the nitrogen treated half of the plots. When applied between June 14—June 28 the sulphate of ammonia produced an effect on the cuts

TABLE III.

Showing Increase in Dry Matter Yield at different stages of growing season due to Nitrogenous Manuring.

Cut.	*Time of Cutting.*		*Lb. gain in Dry Matter.*		*Lb gain per acre.*	
	1931.	*1932.*	*1931.*	*1932.*	*1931.*	*1932.*
1st	Apr. 29—May 19	May 10—May 31	3.58	3.19	573	510
2nd	May 26—June 17	June 7—June 28	2.69	—0.51	430	—82
3rd	June 23—July 16	July 6—July 27	0.66	1.84	106	294
4th	July 21—Aug. 12	Aug. 2—Aug. 24	0.46	3.13	74	501
5th	Aug. 18—Sept. 9	Aug. 31—Sept. 19	—0.05	.89	—9	14
6th	Sept. 22—Oct. 22	—	0.14	—	22	—
			Net increase		1196	1237

immediately following, while its effectiveness was maintained in the fourth cut.

Effect of Nitrogenous Manuring on the Chemical Composition of the Dry Matter.

The effect of the nitrogenous manures on the mineral portion of the herbage in question was similar to that noted from the results of previous experiments, *i.e.*, the concentration of the most important of these was somewhat diminished as a result of the nitrogen application (5). During 1932 a study was made of the effect of the manurial treatment not only on the total nitrogen of the pasture, but also on some of the different forms in which this nitrogen exists in the herbage. The percentage digestible nitrogen was also determined by means of the Stutzer method. The results are summarised in Table IV.

The two moderate dressings of nitrogenous manures (*i.e.*, 160 lb. per acre nitro chalk followed by 160 lb. per acre sulphate of ammonia) have effected a small, but definite increase in the concentration of total nitrogen in the herbage. The increase in protein nitrogen, amino nitrogen and ammonia nitrogen does not fully account for this change in the total nitrogen concentration. This increase in total nitrogen must be mainly accounted for by the increase in the undetermined nitrogenous substances, which include the nitrates of the pasture. These undetermined nitrogen compounds amount to 0.246 per cent. of the dry matter from the

control areas and .340 per cent. of the dry matter of the nitrogen treated areas. It is interesting to note in this connection that evidence has already been brought forward by other workers that

TABLE IV.

Effect of Manuring on the Nitrogenous Constituents of the Herbage (Constituents expressed as percentage of Dry Matter).

Manuring.	*Plot A.*		*Plot B.*		*Plot C.*		*Plot D.*	
	No Nitrogen.	*Nitrogen.*	*No Nitrogen.*	*Nitrogen.*	*No Nitrogen.*	*Nitrogen.*	*No Nitrogen.*	*Nitrogen.*
Total Nitrogen	2.553	2.789	2.657	2.744	2.630	2.674	2.589	2.612
Protein Nitrogen ..	2.124	2.118	2.189	2.171	2.155	2.281	2.148	2.077
Amino Nitrogen .	.149	.156	.200	.168	.161	.151	.155	.166
Ammonia Nitrogen .	.042	.048	.080	.077	.046	.048	.047	.050
Other Nitrogenous Constituents ...	.239	.467	.239	.329	.268	.245	.239	.319
Digestible Nitrogen ...	1.526	1.781	1.778	1.738	1.713	1.718	1.587	1.636

young pastures may under intensive treatment be so high in nitrate that a cow in full lactation might ingest 300 gms. potassium nitrate per day (6).

Effect of Manuring on Yield of Protein Nitrogen.

Table V indicates the crude protein derived from the nitrogen and no nitrogen areas over the two seasons.

Previous reference has been made to the fact that owing to a lower rainfall less dry matter was obtained in 1932 than in 1931. For the same reason it is seen from Table V that the yield of protein in the control areas has diminished by 80 per cent. from season 1931 to 1932 while the yield in the nitrogen treated areas has been diminished by 22 per cent.

The total amount of nitrogen applied as manure per 1/160 acre during each season was equivalent to 2.281 lb. of protein. The average amount of protein recovered from this in the herbage

amounted to 1.339 lb. during 1931 and 1.478 lb. during 1932. This is equivalent to a percentage recovery of 59 per cent. during 1931 and 64 per cent. during 1932.

The significance of the results detailed above is due to the fact that they have been obtained from a pasture previously

TABLE V.

The Effect of Nitrogenous Manuring on the Protein Yield from the Total Cuts of each Plot. (Yield in lb. per 1/160 acre).

Season.	*Treatment.*	*Plot A.*	*Plot B.*	*Plot C.*	*Plot D.*	*Mean.*
1931	No nitrogen	4.906	4.899	5.476	5.527	5.202
	Nitrogen	6.303	6.367	6.658	6.831	6.541
	Increase in Protein Yield due to Nitrogenous Manure	1.397	1.468	1.182	1.307	1.339
1932	No nitrogen	4.435	3.859	3.053	3.284	3.658
	Nitrogen	5.824	5.539	4.645	4.516	5.131
	Increase in Protein Yield due to Nitrogeous Manure	1.389	1.680	1.592	1.252	1.458

treated with nitrogenous manures, and intensively grazed over a period of three years.

When nitrogenous manures are first applied to a soil they encourage microbiological changes which render available to the plant larger supplies of reserve nitrogen than would otherwise be the case. The increased nitrogen in the plant is, therefore, derived from this reserve capital of soil nitrogen as well as from the nitrogen directly supplied in the manure. It has been previously shown that the increased contribution to plant protein made by this reserve soil nitrogen on conversion from the organic to the inorganic form is an important one (2). It does not follow, therefore, that no loss of nitrogen has actually occurred if as much nitrogen happens to be recovered in the herbage as was supplied in the manure. Such a loss may in fact have taken place, although it may not be apparent owing to the enhanced contribution of the soil nitrogren towards the formation of plant protein.

The possibility has to be kept in mind, if repeated doses of nitrogenous manures are applied one season after another, that the effect of such manures in transforming soil organic nitrogen to the inorganic form may be less with the progress of time. Such a condition is more likely to arise where large quantities of nitrogen are annually removed in the form of milk and live weight

increase under an intensive system of grazing. The pertinent question which, therefore, presents itself is—what response can be expected from nitrogenous manures in the case of those swards which have been previously supplied liberally with nitrogen over a number of years, and where all other conditions have been such as to maintain the pasture at a high level of productivity over that period. The data supplied from the experimental plots at the College Farm, Aberystwyth, indicate that under the rainfall conditions prevailing during 1931 and 1932 the loss of nitrogen from soluble nitrogenous manures applied to intensively treated pastures amounted to an average of 38.5 per cent.

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THE EFFECT OF CONTROLLED GRAZING AND MANURING ON NATURAL HILL PASTURES.

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The investigations conducted by the Station on the improvement of natural hill pastures have entailed experimentation on methods of technique whereby results consequent upon treatment could be measured. Earlier investigations on the subject (1, 2, 3) have shown that considerable information can be derived from fenced areas in which plots of the natural pastures were subjected to periodic defoliation with shears and manured with artificial fertilizers.

It was realized, however, that an experiment on similar lines to the previous ones, but using sheep as the defoliators, would provide additional information not only in regard to hill improvement itself but in regard to comparisons of technique whereby such problems can be investigated. Accordingly, such an experiment was begun in the year 1930, and is here reported upon.

Material and Methods.

The experiment (E. 117) was laid down at two hill farms in North Cardiganshire and the swards investigated were :—

1. An open-hill *Festuca-Agrostis* pasture.
2. An open-hill *Molinia* pasture.
3. An enclosed hill *Festuca-Agrostis* pasture.

The first two pastures were at an exposed situation of 900 ft. elevation, the soils being a dry peat and a peat respectively. The former pasture will be referred to as Llety-*Festuca* and the latter as Llety-*Molinia*. The enclosed hill pasture was at an elevation of 850 ft., but was situated in a much more sheltered position and on a light loam soil. This centre will be referred to as Bwlchrosser.

The trial consisted of five fenced 1/100th acre plots at each centre. These plots were treated as follows :—

(1) Lime was applied at the rate of 2 tons per acre of calcium carbonate.

(2) Superphosphate was applied at the rate of 4 cwt. per acre.

(3) Superphosphate was applied as above, with the addition of kainit and sulphate of ammonia at 4 cwt. and 1 cwt. per acre respectively.

(4) As Plot 3, but with the addition of lime at the above rate.

(5) A control plot grazed but receiving no manures.

These plots will be referred to as Ca, P, PKN and CaPKN. In 1931 additional completely manured and control plots were added to each of the Llety centres to obtain hay and aftermath data.

The initial application of manures was made in the spring of 1930. The plots subsequently received each spring superphosphate, kainit and sulphate of ammonia in similar quantities to the above. In addition, sulphate of ammonia at ½ cwt. per acre was applied to the PKN and CaPKN plots after each monthly grazing. This scheme of manuring was also carried out on an unfenced area at each centre. The data derived from these unfenced plots have already been reported upon (4) : the present paper will deal in detail with the fenced plots only.

The plots were subjected to a system of monthly grazing, the commencing date for each year being around the first of May. Six grazings were made per season. The procedure adopted before each grazing was to analyse the herbage according to the percentage productivity estimation method, then to cut ten random samples of the herbage for dry weight, using an iron mesh having an inside measurement of one square foot. Welsh mountain sheep which had been brought to the plots in the Station lorry were placed on the plots and allowed to graze for two or three days. As the centres were at a distance from the Station the number of sheep required to consume the herbage of each plot had to be estimated beforehand. A further set of ten samples per plot were taken at the completion of the grazing. The pooled weight of these post-grazing samples was subtracted from the pooled weight of the subsequent pre-grazing samples for the respective plots (taken a month later) in order to obtain the net growth made during the month.

The method of analysis has been described by Stapledon and Thomas (1) and also by Davies and Jones (2).

Results.

Pasture : (*a*) *Total Yields.*

The total yields of edible herbage have been recorded over a

TABLE I.

Annual yields of herbage, exclusive of moss and inert matter, in cwt. (=100 lb.) of air-dry fodder per acre for the first three years of the trial.

Centre.	*Plot.*	*Year.* 1930.	1931.	1932.	*Average Yield.*
Llety-*Festuca*	CaPKN	31.2	38.0	27.2	32.1
	PKN	31.0	39.0	28.4	32.8
	Ca	23.3	28.0	24.9	25.4
	P	28.7	27.5	37.9	31.4
	Control	15.4	19.9	25.7	20.3
Bwlch-rosser	CaPKN	24.9	35.8	44.2	35.0
	PKN	26.9	49.4	42.4	39.2
	Ca	20.3	29.5	22.1	24.0
	P	16.7	28.7	31.4	25.6
	Control	15.0	22.5	25.0	20.8
Llety-*Molinia*	CaPKN	22.1	34.9	20.1	25.7
	PKN	22.0	32.1	21.7	25.3
	Ca	12.0	14.2	9.1	11.8
	P	13.0	18.5	17.5	16.3
	Control	13.2	8.7	7.8	9.9

period of a complete year. These are shown in Table I (page 198) for the first three years of the trial. The yields for the fourth year (1933) were not complete owing to an end of April sampling for 1934 not being available.

The data show the marked increase in yield of the completely manured plots in comparison with the control plots. The CaPKN and PKN treatments have given practically similar yields at the two Llety centres, while those at Bwlchrosser were very similar for 1930 and 1932. The P plots gave, on the whole, larger yields than either the Ca or the control plots. This is particularly marked for 1932, which fact tends to indicate that manuring with superphosphate was having an accumulative effect. Ca had a decided influence upon the yield, the average yields for the three years being much superior to those for the control. Calcium alone, however, has proved more effective in increasing the yield on the two fescue swards than on the *Molinia* sward. It is evident that the controlled grazing had a beneficial effect upon the unmanured plots at Llety-*Festuca* and Bwlchrosser. At Llety-*Molinia*, on the other hand, the annual yields of this plot became progressively poorer. The average annual yields for each treatment at the Llety-*Molinia* centre were smaller than the respective yields at the fescue-bent centres.

(*b*) *Winter and early spring growth.*

The value of edible herbage during the winter and early spring periods can hardly be exaggerated, and this factor has been investigated at the Station in connection with the work on hill pasture improvement.

TABLE II.

Winter yields of herbage, exclusive of moss and inert matter, in cwt. (=100 lb.) of air-dry fodder per acre. Average figures for three winters.

	Plot.				
Centre.	*CaPKN.*	*PKN.*	*Ca.*	*P.*	*Control.*
Llety-*Festuca*	5.2	4.6	3.5	3.0	2.6
Bwlch-rosser.	4.5	4.5	3.7	3.7	1.5
Llety-*Molinia*	2.8	2.2	1.6	2.5	0.9

In the present paper, the yields for the winter period, October to April inclusive, are given in Table II.

The data show the marked superiority of all the treated plots in comparison with the unmanured. The two completely manured plots have exceeded Ca and P on the fescue-bent swards, but they have not given larger yields than P at the *Molinia* centre. It is interesting to find that for this winter period calcium alone was more effective on the fescue-bent swards than on the *Molinia*, as was also the case for the total annual yields. The small yield of the unmanured plot at the *Molinia* centre, compared with the unmanured plots at the other centres, illustrates the natural poverty of these *Molinia* pastures during this period. The data

TABLE III.

Distribution of yield during the first and last years of the trial expressed as percentages of the aggregate yield from May to September.

Centre.	*Year.*	*Plot.*	*Month.*				
			May.	*June.*	*July.*	*August.*	*September.*
Average of Llety-*Fescue* and Bwlch-rosser	1930	CaPKN	17	16	27	19	21
		Control	18	13	40	10	19
	1933	CaPKN	16	12	28	26	18
		Control	16	15	19	32	18
Llety-*Molinia*	1930	CaPKN	20	32	26	16	6
		Control	17	24	39	11	9
	1933	CaPKN	19	11	27	22	21
		Control	15	7	28	28	27

as a whole clearly indicate that the use of fertilizers with controlled grazing enables the yields of these natural pastures to be considerably increased at a critical period.

(*c*) *Seasonal Yield.*

The distribution of the yields for the completely manured and control plots over the period May to September are given in Table III (page 200).

The data indicate that during the first year the mid-seasonal yields of the control plots were not as well distributed as the yields of the completely manured plots. By the fourth year, however, the two classes of plots had become more similar in this respect. The marked difference in the figures for August and September at the *Molinia* centre is interesting. It will presently be shown that before 1933 the *Molinia* herbage had changed to a fescue-bent herbage. This change in botanical composition has entirely altered the distribution of the yield, consequently, both the manured and the control plots resemble the fescue-bent centres for the fourth year data in regard to August and September productivity. This difference in the seasonal productivity at the *Molinia* centre as between the first and the fourth year of the trial is again shown in the June figures. The " peak " growth of *Molinia* caused the high percentage in yield at that period in 1930.

(*d*) *Contribution of the Species to the Yield.*

The analyses made on the herbage before the monthly grazings have provided data on the contribution of the individual species to the yield. These data, for the first and last years of the trial, have been averaged for the two fescue-bent centres and are given in Table IV, while the corresponding data for the *Molinia* centre are presented in Table V. For the purpose of these particulars the winter period 1932-33 has been taken in order to complete the final year.

Considering Table IV first, it will be seen that fine-leaved fescue (*Festuca ovina* L. and F. *rubra* L.) and bent (*Agrostis* species) are the chief contributors to the yield. The main difference in botanical composition between Llety-*Festuca* and Bwlchrosser was that the herbage at the latter centre contained small amounts of wild white clover (*Trifolium repens* L.) and *Lotus corniculatus* L., whereas the herbage at the former centre contained no legumes.

The chief point disclosed by the data is that by 1933 in the

CaPKN, PKN and P plots, bent has largely replaced fescue, and bent has almost equalled the yields of fescue on the Ca and control plots. That this botanical change occurred on

TABLE IV.

Annual yields of the species in cwt. (=100 lb.) per acre of air-dry fodder for the first and last years of the trial. Average figures for Llety-Festuca and Bwlchrosser.

Plot.	Year.	*Fine-leaved fescue*	*Agrostis species.*	*Sweet vernal.*	*Wild white clover.*	*Miscellaneous species.*	*Moss and inert matter.*	*Total yield.**
CaPKN ...	1930	16.0	8.5	1.5	0.3	2.7	0.3	29.0
	1933	16.0	20.2	1.7	0.1	2.4	1.0	40.4
PKN ...	1930	17.0	8.9	1.1	Trace.	2.8	0.8	29.8
	1933	12.4	36.6	1.9	Trace.	2.3	1.8	53.2
Ca ...	1930	13.0	6.1	0.9	Trace	2.5	0.9	22.5
	1933	11.2	10.2	1.0	0.3	4.2	0.9	26.9
P ...	1930	18.8	6.4	0.7	0.1	2.3	0.9	28.3
	1933	11.3	14.9	1.8	1.1	1.5	1.5	30.6
Control ...	1930	9.2	4.8	0.4	Trace	1.7	0.9	16.1
	1933	8.2	7.4	0.4	0.2	2.6	0.9	18.8

* Excluding moss and inert matter.

Miscellaneous species: *Potentilla erecta*, Hampe. *Galium saxatile* L., *Luzula campestris*, Br. and *Carex* species.

the unmanured plots is particularly interesting, for the conclusion to be drawn is that the effect of controlled grazing was in a large measure the responsible factor. The application of

fertilizers, particularly in a complete form, evidently had an enhancing effect upon this change in the botanical composition of the pastures.

The actual yields of miscellaneous species have slightly decreased by the fourth year under three of the treatments, but they have materially increased for the Ca and control plots.

TABLE V.

Annual yields of the species in cwt. (= 100 lb.) per acre of air-dry fodder for the first and last years of the trial at the Llety-Molinia centre.

Plot.	*Year.*	Molinia caerulea.	*Fine-leaved fescue.*	Agrostis *species.*	Nardus stricta.	*Miscellaneous species.*	*Moss and inert matter.*	*Total yield.**
CaPKN	1930	8.5	10.1	1.7	3.3	0.5	1.3	24.1
	1933	Trace	11.1	15.3	2.0	0.7	0.7	29.1
PKN	1930	8.1	8.3	1.6	2.8	0.2	2.0	21.0
	1933	0.1	6.6	24.7	0.7	0.2	1.0	32.3
Ca	1930	7.0	3.1	0.1	0.8	0.6	1.4	11.6
	1933	2.0	9.7	1.2	0.7	1.1	0.7	14.7
P ...	1930	6.6	5.1	0.5	1.4	1.4	2.2	15.0
	1933	3.4	10.3	12.4	1.0	1.9	1.3	29.0
Control	1930	8.5	2.5	0.1	1.2	0.4	3.3	12.7
	1933	0.9	6.2	2.1	1.2	0.2	0.4	10.6

* Excluding moss and inert matter.

Miscellaneous species: *Vaccinium* **Myrtillus** L., *Calluna* and *Erica* species, *Juncus* **squarrosus** L., *Scirpus caespitosus* L., and *Carex* species.

A comparison of the total yields shows the greater productivity of all plots by the fourth year, particularly of the completely manured plots.

If the data in Table V (page 208) are examined, it will be observed that the composition of the herbage had changed considerably over the period of the trial, particularly in the CaPKN and PKN plots. The *Molinia* itself (*Molinia caerulea* Moench) had largely died out under the influence of the treatment and its place had been taken by fescue and bent. The yields of fescue and bent at this centre are of great interest, for bent had not only surpassed fescue by the fourth year, but it had done so in precisely the same plots as at the other centres, namely, CaPKN, PKN and P.

Other changes are that *Nardus stricta* L. has decreased in all plots except the unmanured, and that the change over from a *Molinia* to a fescue-bent pasture has resulted in much less "burn" in the herbage. This is reflected in the marked decrease in the figures for inert matter for the fourth year.

In order to show the behaviour of the dominant species in the second and third years of the trial, the percentage contribution of bent to the herbage of the Llety-*Festuca* and Bwlchrosser centres, and of bent plus fine-leaved fescue to the herbage of Llety-*Molinia* is given in Table VI for the July growth of each

TABLE VI.

Percentage contribution for the July growth of each year of Agrostis spp. to the herbage of Llety-Festuca and Bwlchrosser, and of Agrostis spp. plus fine-leaved fescue to Llety-Molinia.

Centre.	*Plot.*	*Year.* 1930.	1931.	1932.	1933.
Average of Llety-*Festuca* and Bwlchrosser	CaPKN	32	45	43	59
	PKN	39	39	54	65
	Ca	26	39	39	40
	P	24	37	42	46
	Control	27	27	35	40
Llety-*Molinia*	CaPKN	25	90	90	99
	PKN	14	85	92	95
	Ca	8	56	79	88
	P	11	58	79	75
	Control	7	29	56	76

year. The proportion of bent to fescue was fairly constant throughout the monthly grazings, so that the mid-season growth of July gives a fair comparison.

The data from the fescue-bent centres show the consistent

increase of bent over fescue throughout the years. This increase was more pronounced in the CaPKN and PKN plots, particularly by the third and fourth years. The most striking fact which the figures disclose is the great decrease of *Molinia* and consequent increase of bent and fescue at the *Molinia* centre. In the completely manured plots this change in the botanical composition was practically completed after one season's treatment.

The control plot retained *Molinia* herbage to a greater degree than any of the other plots, while, on the other hand, the facility with which the change was made on the Ca plot is worthy of note.

The Stocking of the Plots.

A record was kept of the number of sheep required to consume the herbage of each plot throughout the period of the trial. These data expressed in sheep days and in number of sheep per acre per year, are given in Table VII.

TABLE VII.

Stocking required to consume the herbage expressed as sheep-days per acre per year, and (in brackets) sheep per acre per year. Average figures for four years.

	Plots.				
Centre.	*CaPKN.*	*PKN.*	*Ca.*	*P.*	*Control.*
Llety-*Festuca*	2680 (7.4)	2730 (7.5)	1750 (4.8)	1800 (4.9)	1450 (4.0)
Bwlch-rosser	2800 (7.7)	3000 (8.3)	1650 (4.5)	1650 (4.5)	1450 (4.0)
Llety-*Molinia*	2750 (7.6)	2800 (7.7)	1450 (4.0)	1500 (4.1)	1880 (8.7)

When considering these figures it is to be clearly understood that they have no relation to the natural stock-carrying capacity of the grazing land in question, but that sheep, to the number shown, were required to consume the herbage on the plots. For instance, the area at Llety-*Festuca* on which the plots are situated is 800 acres in extent, and 600 ewes with their lambs graze there during the season. The number of sheep carried on the unmanured plots of the trial was almost double this stocking. The figures, therefore, should be regarded as being of value in comparing plot with plot within the experiment, and not as an

indication of what could be done in practice if these treatments were carried out on a large scale.

The data show that much heavier stocking was required on the completely manured plots as compared with the other treatments, and also that the Ca, P and control plots at the two fescue-bent centres carried more sheep than the corresponding plots at the *Molinia* centres.

Hay with Aftermath.

As previously mentioned, additional completely manured and unmanured plots were added to the Llety-*Festuca* and Llety-*Molinia* centres in 1931 from which hay and aftermath yields were taken. These data are given in Table VIII.

It will be observed that the sum yields of hay and aftermath increased markedly in 1932 and 1933 compared with the first year for both plots at each centre. The yields at the fescue-bent centre exceeded the corresponding yields at the *Molinia* centre. In regard to the individual species, fescue and bent at the Llety-*Festuca* centre were approximately equal in the first year, but in the manured plot bent greatly exceeded fescue in the subsequent years. In the unmanured plot, on the other hand, bent only slightly exceeded fescue by the third year.

At the *Molinia* centre the yields of that grass progressively increased over the years of the trial on the manured and the unmanured plots. In the former plot, however, fescue far exceeded *Molinia* in the second year, while bent almost equalled it. The relative proportions were still greater by the third year. Unlike the behaviour of fescue and bent at the Llety-*Festuca* centre, the yields of bent did not exceed those of fescue. In the unmanured plot, in contra-distinction to its behaviour on the pasture plot, *Molinia* maintained its position as dominant contributor to the yields throughout the period of the trial. Bent scarcely gave any increase in yield, but *Nardus* gave greater yields in both plots.

Discussion.

When the data from the pasture section are contrasted with those from the hay and aftermath section of the trial several facts appear which illustrate the striking effect of management upon the natural swards.

It is not possible to compare the total produce obtained by the two methods of management, as these were begun on different

TABLE VIII.

Yields of hay with aftermath in cwt. (= 100 lb.) of air-dry fodder per acre.

Centre.	*Plot.*	*Year.*	Species.						*Total yield.*
			Molinia caerulea.	*Fine leaved fescue.*	Agrostis *species.*	Nardus stricta.	*Sweet vernal grass.*	*Miscellaneous species.*	
Llety-*Festuca*	CaPKN	1931	—	6.1	7.1	—	1.0	0.1	14.3
		1932	—	8.2	18.4	—	0.5	0.1	27.2
		1933	—	15.8	46.5	—	0.2	0.4	62.9
	Control	1931	—	4.6	4.4	—	0.5	0.2	9.7
		1932	—	10.1	9.7	—	0.8	1.3	21.4
		1933	—	8.0	10.5	—	0.1	1.2	19.8
Llety-*Molinia*	CaPKN	1931	2.9	0.7	0.1	0.4	—	0.1	4.2
		1932	3.5	8.2	3.8	1.1	—	1.1	17.2
		1933	10.8	28.1	18.1	1.4	—	1.1	59.5
	Control	1931	3.1	0.2	0.1	0.8	—	0.2	3.9
		1932	2.6	1.8	0.4	0.8	—	0.6	6.2
		1933	7.2	4.4	0.4	1.2	—	0.2	13.4

dates, but the relationship of the treatments within each section can be studied.

The yields of the Llety-*Festuca* centre exceeded the corresponding yields of the *Molinia* centre under both methods of management, but whereas the pasture yields were relatively high in the first year compared with the subsequent years, the hay with aftermath yields greatly increased from the first to the third year.

Another point of similarity is that at the Llety-*Festuca* centre bent increased to a great extent compared with fescue, particularly on the CaPKN plot. On the other hand, whereas bent exceeded fescue on the CaPKN plot of the *Molinia* centre under pasture, such was not the case under hay conditions. Moreover on the pasture and hay control plots of the same centre bent gave an appreciably increased yield under pasture, but under hay with aftermath it gave practically no increase in three years of treatment. The actual yields of *Molinia* decreased in the pasture plots from year to year, but under hay they increased with the one exception of the control yield for 1932. In this control plot the *Molinia* remained the highest contributor to the total yield throughout the trial. *Nardus* decreased in yield in all the treated plots under pasture, but increased in the two plots under hay and aftermath.

It is apparent, therefore, that from the point of view of quality of herbage, pasture conditions are more favourable than hay conditions where a *Molinia* sward is concerned. This is the case in particular when the herbage is unmanured, for then pasture conditions are necessary to effect the desired change in the botanical composition. The superiority of a fescue-bent sward as compared to a *Molinia* sward has been fully discussed in the earlier investigations. Even when a *Molinia* sward is completely manured, however, pasturing is necessary to enable the bent to become dominant over the *Molinia* itself and the fine-leaved fescue. That the ascendancy of bent over fescue is a desirable change in the botanical composition of hill pastures is made evident by the data obtained from this trial, for bent has made a greater response to the methods of improvement than has fescue. Moreover, of the two grasses, bent is somewhat more palatable to stock, as has been shown by the writer in a previous report (5).

In an earlier investigation referred to above, Stapledon and Thomas (1) point out that the results they obtained by the use of shears would not necessarily be the same had the grazing animal been used. In the statement below the yields of edible herbage in cwt. (= 100 lb.) per acre of air-dry fodder obtained

by these investigators from the Llety-*Festuca* centre, also those obtained by Davies and Jones (2), together with the yields from the present work are shown :--

	Reference (*1*)	*Reference* (*2*)	*Present work.*
CaPKN	—	34.5	34.6
PKN	11.7	—	35.0
Ca	—	20.3	25.7
P	13.8	13.4	28.1
Control	9.0	11.2	17.7
	Average of seasons 1927 and 1928.	Season 1929.	Average of seasons 1930 and 1931.

When comparisons are made between the treatments within the separate trials it is seen that the results obtained by the use of sheep in the present work differ to a marked extent in some respects from the results of the two previous experiments.

The chief difference is that there is not nearly such a wide margin between the yields of the CaPKN and PKN plots on the one hand, and those of the Ca, P and unmanured plots on the other hand when sheep are used as when the herbage is cut with shears. The effect of the grazing animal is particularly marked in the control (unmanured) plot.

A second difference is that under sheep phosphate alone has proved more effective in increasing the yield than has calcium alone, but with cutting the opposite was the case. Calcium, however, greatly increased the yield under both methods of defoliation. It has been shown, moreover, that calcium affects the grazing in a direct way and not only through the medium of botanical change (4).

In all the investigations the effect of pasture treatment, whether by cutting or grazing, upon a *Molinia* sward has resulted in the *Molinia* dying out to a large extent and the initially small quantities of fescue and bent increasing and taking its place. There is, however, a difference in the degree to which this occurs. Under the cutting system the change was rapid and complete in the CaPKN plot, but in the unmanured plot, although the *Molinia* was reduced, there was little replacement by fescue and bent. Under sheep, on the other hand, these two species increased in the unmanured plot, although not as rapidly in the early years as on the other plots.

In regard to this same question of botanical change on a *Molinia* pasture, Jones (3) working with two nitrogenous fertilizers found that nitro-chalk gave an increased yield in the second year of the trial and changed the sward into one of bent, while sulphate of ammonia gave a decrease in yield in the second year and made little change in the flora. It is interesting to note in this connection that in the present trial when sulphate of ammonia was supplemented by superphosphate, kainit and again by lime the composition of the herbage was changed whether grazed or cut for hay and aftermath.

Summary.

An investigation into the improvement of three hill pasture types has been made by means of controlled grazing and the application of fertilizers.

Grazing alone benefited the unmanured plots of the fescue-bent swards but depleted the unmanured plot of the *Molinia* sward.

Complete manuring gave the greatest increase in yield. The addition of calcium to nitrogen, phosphates and potash did not influence the yield, but phosphates and calcium applied singly had a marked effect upon yield. The increase in yield following the application of calcium was greater on the fescue-bent swards than on the *Molinia* sward.

The data showed that the yield of the pastures investigated could be considerably increased during the winter and early spring, and the natural poverty of a *Molinia* pasture at that period has been illustrated.

Complete manuring brought about a more uniform distribution of the yield over the season, particularly on the *Molinia* pasture.

The experimental treatment resulted in certain changes in the botanical composition of the swards. On the fescue-bent swards, fescue was largely replaced by bent and the data showed that the grazing factor was the one chiefly responsible. The fertilizers had an enhancing effect upon this change. On the *Molinia* sward the *Molinia* was greatly depressed in yield and its place taken by bent and to a lesser extent by fescue.

The completely manured plots of the three pastures carried approximately the same number of sheep, but the calcium, phosphate and unmanured plots of the fescue-bent pastures carried more sheep than these plots on the *Molinia* pasture.

Comparisons between pasture data and hay with aftermath

data showed that pasture conditions surpassed hay conditions in promoting quality of herbage at the *Molinia* centre.

Reference to previous work on hill improvement showed that defoliating the herbage by the natural method of sheep grazing has had the effect of rendering the yields of the calcium, phosphate and unmanured plots more akin to the yields of the plots having complete fertilizing. The influence of the sheep also caused the change from a *Molinia* pasture into a fescue-bent pasture to be more marked in the unmanured plot.

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TRIALS WITH STRAINS OF COCKSFOOT AND OBSERVATIONS ON THE POLICY OF THE STATION IN RELATION TO THEIR DISTRIBUTION AND USE.

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The breeding work with cocksfoot (*Dactylis glomerata* L.) has now advanced a considerable way. Five main types of strains bred at the Station have been subjected to sward tests, These are ;—

(1) *Pasture-hay type as exemplified by S.26* (=Bc 1168).

This strain is now available on a commercial scale and affords an excellent example of a good indigenous cocksfoot. The plants are profusely tillering, very leafy and moderately high. As spaced individuals they are larger and less spreading than typical pasture plants and not as erect or as well "leafed-up" as typical hay plants.

(2) *The Leicestershire pasture type.*

The plants are more profusely tillering than in any other type; the leaves are decidedly narrow and the inflorescences and seeds relatively small. The individual plants are particularly dense.

(3) *Broad-leaved spreading pasture.*

A number of strains conforming to this type are under trial. The plants are dense growing and spreading with broad leaves and large seeded panicles. Evidence has shown that broad leaves are more palatable than narrow leaves and that large seeds give rise to established seedlings on a more generous scale than do small seeds. If these strains prove to be persistent, all the indications are that it is from amongst their representatives included in our breeding material that we shall select the most valuable pasture strain for ultimate distribution.

(4) *Pasture-tussock type.*

The representative strains of this type have not the exaggerated characteristics of either the "Leicestershire" or the "broad leaved spreading pasture." The plants are large with fairly broad leaves. As spaced individuals they form considerable sized tussocks. The panicles are intermediate in size and the seeds comparatively large.

(5) *Dense hay type.*

A definite objection to all the pasture and *quasi*-pasture types is the fact that they start growth appreciably later in the spring than the ordinary Danish commercial. In recent years endeavour has therefore been made to breed a hay type giving dense and leafy plants which are yet erect and tall and make earlier spring growth than the stemmy and lax Danish plants.

Trials have been conducted over a period of upwards of ten years with the pasture-hay type (S.26 and closely related strains). The other strains have only been brought into field trials during

the past three years. Results of numerous trials with the pasture-hay strain in comparison with ordinary Danish and New Zealand strains have been reported upon.[1] We shall here give results from more recent trials with these three strains, and then bring under review the trials so far conducted with the complete series of strains. The chief characteristic with which we have been concerned is persistency, and it is with this important property that for the most part we shall here deal.

Pasture-hay strain compared to Danish and (or) New Zealand cocksfoot. Pure plots.

The results given in Table I were obtained on pure plots at a number of different centres and show the relative persistency of the strains at the end of the third, fourth and sixth harvest years.

TABLE I.

To show the number of tillers of cocksfoot per 2½ sq. ft. on pure plots sown at a number of different centres.

Expt. no., Centre and approximate height above sea level.	*Harvest year.*	*Strain of cocksfoot.*	*No. of tillers per 2½ sq. ft.*	*Danish as 100. Relative per cent.*
E. 36. I. Spring Field: 306 ft.	6th	Bc 2 1 pasture-hay	204	658
		Danish	31	100
E. 73. III. Foel: 800 ft.	3rd	Bc 1163 Pasture-hay	534	834
		Danish	160	100
E. 73. III. Foel: 800 ft.	4th	Bc 1163 Pasture hay	470	389
		Danish	121	100
E. 73. II. Nantsiriol: 40 ft.	4th	Bc 1163 Pasture-hay	262	391
		Danish	67	100
E. 37. II. Foel: 800 ft.	4th	Bc 1163 Pasture-hay	162	953
		Danish	17	100
E. 37. II. Pensarn: 700 ft.	4th	Bc 1163 Pasture hay	187	2077
		Danish	9	100

The figures show that in all cases the persistency of the pedigree pasture-hay strains has been vastly superior to that of the ordinary Danish commercial. Fourth harvest year results are available for lowland (Nantsiriol) and upland (Foel and Pensarn) centres. Taking the data as a whole it is evident that at the more exacting centres the pasture-hay strain has shown to even better

[1] See for example (1), (2), and (3).

advantage compared to Danish than at the lowland centres. A comparison of the results given in the third and fourth harvest years at one and the same centre, and in the same experiment (E.73 III), indicates that the tiller population falls off in all strains as the years advance, but that the pasture-hay strain maintains its position very much better than the ordinary Danish cocksfoot. It should be pointed out that in the case of all the experiments the plots were grazed after the first harvest year, and under these conditions, even on the lowlands, the Danish cocksfoot has dwindled to very small proportions by the fourth harvest year (Nantsiriol) and to even smaller proportions by the sixth harvest year (Spring Field). The pasture-hay strain, although relative to Danish remaining wonderfully persistent on the uplands, does not, however, maintain itself as well under upland as under lowland conditions.

In simple mixtures.

An experiment (E.61 VII) was put down an Penwenallt (lowlands) in 1925. Four strains of cocksfoot were sown in separate plots as components of a simple mixture otherwise similar. The strains employed were Danish, pasture-hay (Bc 1163) and two indigenous strains obtained commercially both of which were of the pasture-hay type. Tiller counts were made in the fourth harvest year and the results for the strains of cocksfoot are shown in Table II.

TABLE II.

To show the number of tillers per 2½ sq. ft. for four strains of cocksfoot in the fourth harvest year when sown in simple mixtures.

Strain.	*No. of tillers.*	*Relative.*
Danish	142	100
Pasture-hay : commercial (*a*)	260	183
Pasture-hay : commercial (*b*)	316	223
Pasture-hay : Bc 1163	327	230

Here the results are in the same direction as those given by pure plots. The advantage is wholly with the pasture-hay strains in comparison with the Danish. It is of interest to note that one of the commercially obtained pasture-hay strains was very decidedly superior to the other and that Bc 1163 proved itself the most persistent of the strains under test.

An experiment (E. 122) concerned with different intensities of grazing prior to putting-up for hay was laid down at Foel

(800 ft. above sea level) in 1930. This important experiment will be reported upon in detail elsewhere; the generalized evidence relative to cocksfoot may, however, usefully be considered in the present connection.

Hay was taken in the first and again in the second harvest year, and in the third harvest year the plots were grazed. The second and third harvest year results are of chief interest and it is only these that we shall consider.

The basal seeds mixture employed consisted (in lb. per acre) of Italian rye-grass 4; cocksfoot 16; crested dogstail 6; red fescue 10; Montgomery red clover 8, and wild white clover 2. In one series of plots the cocksfoot was Danish, in the second series New Zealand, and in a third series pasture-hay (Bc 1168). Each series was replicated five times.

The most instructive data for the second harvest year (hay) are set out in Table III.

TABLE III.

Second harvest year hay data in respect of the behaviour of three strains of cocksfoot when included in simple mixtures.

Strain of cocksfoot.	*Cocksfoot.* *Percentage productivity.* Stem.	Leaf.	Stem + leaf.	Yield as hay in cwt. per acre.	*Percentage productivity of* Crested Dogstail.	Montgomery red clover.	*Total yield of hay crop in cwt. per acre.*
Pasture-hay ...	6.7	11.2	17.9	5.6	31.0	39.0	31.4
Danish ...	6.5	3.7	10.2	3.3	30.0	10.0	32.3
New Zealand	4.1	5.1	9.2	3.2	28.0	44.0	34.7

The plots were put-up to hay late, not until well into May. Under these conditions the contribution of crested dogstail to the hay crop was remarkably high—on the average of all the plots just under 30 per cent.—compared to 12.6 per cent. given by cocksfoot.

This is an incidental piece of evidence in the present connection, but is of sufficient importance to merit attention. The results obtained at the Station have emphasized the importance of crested dogstail as a hay grass for use on poor soils for leys that are habitually put-up to hay late, and here we have significant corroborative evidence. The Montgomery clover has behaved in precisely the same way as the crested dogstail and both these

(late) species have been favoured at the expense of the cocksfoot by the late putting-up. It is the Montgomery clover that has predominantly influenced the hay yields. The New Zealand cocksfoot plots which yielded the least cocksfoot and the most red clover gave the heaviest hay yields, while the pasture-hay cocksfoot plots which yielded the most cocksfoot and the least red clover gave the lowest hay yields. The Danish (cocksfoot) plots with an intermediate clover : cocksfoot ratio also took an intermediate position in respect of hay yield.

From the point of view of cocksfoot yield and cocksfoot contribution as such it will be noted that the pasture-hay strain gave very decidedly better results than either the Danish or the New Zealand strains. The pasture-hay strains do not always outyield the Danish as soon as the second harvest year, but they invariably do so on fields comparatively low in the scale of fertility when such fields are put-up to hay late. A result that is largely due to the fact that the early Danish strain is punished to a considerably greater extent by the April grazing than is the late pasture-hay strain. In this particular trial the New Zealand cocksfoot showed to no advantage (second harvest year) compared to the Danish, except that it contributed a more leafy herbage to the hay, in which respect, however, it fell considerably behind the pasture-hay strain.

In the third harvest year the plots were grazed, and the figures given below show the persistency of the three strains as estimated by tillers per 2½ sq. ft. with relative figures in brackets :—

Pasture-hay	329	(283)
Danish	116	(100)
New Zealand	178	(158)

There is no mistaking the altogether better persistency of the pasture-hay strain than of the other two. As is usual in the third harvest year, the New Zealand strain shows somewhat better persistency than the Danish.

The five types of strain bred at the Station compared to Danish cocksfoot.

Drill trial. A large number of pedigree strains was sown in replicated 20 ft. drills on the Knoll in 1932. The produce was cut and weighed green (in the afternoon during a spell of very fine weather) at hay time in the first harvest year (1933). The average weights per drill for the five types of strain mentioned

earlier in this article in comparison with Danish are given hereunder :—

"Leicestershire" pasture	3.4 lb. per 20 ft. drill.
Broad-leaved spreading pasture	3.6 lb. per 20 ft. drill.
Danish	3.7 lb. per 20 ft. drill.
Pasture-hay	4.2 lb. per 20 ft. drill.
Pasture-tussock	5.0 lb. per 20 ft. drill.
Dense hay	4.8 lb. per 20 ft. drill.

The figures are only of interest as showing that the more definitely spreading and late types do not yield well in a first harvest year, while the more erect and definitely erect (*e.g.* dense hay) types, although late, are capable of high yields even in the first harvest year. The Danish cocksfoot appeared to be more affected by the drought than the Station strains and did not therefore show to as good advantage in this, the first harvest year, as is usual.

Pure plot trial. A series of comparatively large but non-duplicated pure plots were sown down on the Bank Field (poor thin soil) in 1930. Tiller counts and yields per acre are available for the first harvest year (1931) and tiller counts for the second harvest year. The average results for the different strains are shown in the statement hereunder for the two harvest years :—

Strain of cocksfoot.	*Yld. in cwt.* (= *100 lb.*) *per acre first harvest year.*	*Tillers per $2\frac{1}{4}$ sq. ft.* *First harvest year.*	*Tillers per $2\frac{1}{4}$ sq. ft.* *Second harvest year.*
Danish	11.9	320	821
Dense hay	9.3	165	541
Pasture-hay	9.4	560	682
Pasture-tussock	10.4	449	627
Spreading pasture	8.6	139	567
Leicestershire pasture	6.4	665	838

Here the Danish strain yielded normally and, as is most frequent, gave a higher yield than the later and more persistent strains in the first harvest year.

The pasture-tussock, as in the drills, gave the heaviest hay yield of the pedigree strains closely followed by dense-hay and pasture-hay. The two essentially pasture strains were the poorest yielding. The more highly tillering pedigree strains give more tillers per unit of area than the Danish, even in the first harvest year, a state of affairs which is accentuated in the second harvest year. In the second harvest year the excessive tillering capacity of the "Leicestershire" pasture strain shows to marked

advantage. The broad-leaved spreading pasture and the dense-hay although not so abundantly tillering as the other pedigree strains none the less show promise of good persistency, and are vastly superior to the Danish in this important respect.

Simple mixture trial. A trial was set up on the Rhydtir Field in 1931. Seven different strains of cocksfoot were superimposed upon a basal mixture in as many different plots. The mixture was as follows in lb. per acre :—the particular cocksfoot strain 14; pedigree meadow fescue 14; pedigree timothy 8; with 1½ lb. each of crested dogstail and rough-stalked meadow grass; Montgomery red clover 4, and wild white clover 1 lb. of pure seed and 1 lb. of " cleanings ".

The plots were about ¼ acre and ran lengthwise across the field. This particular field stands on a hillside opposite to the main block of the Plant Breeding Station Farm and almost from the outset has been of considerable general interest. The seven different strips have stood out quite clearly, primarily as the result of the different shades of green of the several strains of cocksfoot. In the second year, however, the Danish plot showed a more marked difference in colour consequent upon a great reduction in the stand of cocksfoot.

In the first harvest year the field was put up to hay, but only after being grazed right into May. It is of interest to note that under these conditions crested dogstail contributed more to the hay than any other species. The contribution of this grass did not fall below 26 per cent. on any of the plots, and exceeded 40 per cent. on the plot to which the Danish cocksfoot (itself severely handicapped by the long period of grazing) contributed.

The percentage contribution to the hay crop (first harvest year) of the several strains of cocksfoot and the number of tillers per 2½ sq. ft. in the second harvest year are shown in the statement hereunder :—

Strain of cocksfoot.	*Percentage contribution to the hay crop, first harvest year.*	*Tillers per 2½ sq. ft., second harvest year.*
Danish	5.5	99
Dense-hay	20.7	365
Pasture-hay	18.2	463
Pasture-tussock	11.8	120
Spreading-pasture (average of two lots)	6.4	317
Leicestershire pasture	10.0	368

The very slight contribution of the Danish cocksfoot even to the first year's hay crop shows the extent to which this strain was handicapped relative to all the indigenous strains by the hard spring grazing. The field was heavily grazed on the aftermath and again during the spring of the second harvest year, with the result that the indigenous strains show to even better relative advantage than is usual in the sward of the second year. The good performance of the dense-hay strain both in the first harvest year and as to persisting into the second year is noteworthy and decidedly encouraging. The pasture-hay and pasture-tussock strains have both shown to good advantage. The " Leicestershire " pasture strain in this particular experiment has not shown to its usual advantage in tillering capacity. The very hard grazing had here permitted a fairly good contribution from wild white clover (by the second harvest year) even on the plots sown with the indigenous strains of cocskfoot, but even so there was more white clover on the Danish plot. On the basis of tiller estimations wild white clover made a contribution of 17.7 per cent. on the Danish plot and an average contribution of 11.3 per cent. on the indigenous plots.

Summary and Practical Conclusions.

This summary may usefully be made to embrace all the evidence so far obtained at the Station relative to strains of cocksfoot and not merely the explicit results brought forward in the present paper.

(1) When cocksfoot is included in seeds mixtures intended for leys from which hay will be taken in the earlier harvest years, the amount of such cocksfoot contributing to the hay will be influenced to a marked degree by the date at which the field is put up to hay. Broadly speaking, the shorter the pre-hay grazing period the greater will be the contribution to the hay. The various pedigree strains (all based on indigenous stocks), because later to start growth than ordinary Danish commercial, are less impeded by pre-hay grazing than the latter earlier and more erect strain.

(2) The ordinary Danish cocksfoot is not only the earliest to start growth in the spring, it is also more erect in growth than the pedigree strains derived from indigenous stocks. When still abundant on the field the Danish is, therefore, punished to a greater extent than the indigenous by the grazing animal. This in part undoubtedly accounts for the greater persistency of the pedigree strains. The evidence as a whole seems to suggest, moreover, that particular pedigree strains are persistent not only in

proportion to their inherent tillering capacity, but also in proportion to the spreading and close growing nature of their leafage.

(3) Persistency appears also to some extent to be a function of width of leaf. The narrower leaved strains are not so palatable to stock as those with broader leaves. The narrow-leaved strains (e.g. Leicestershire pasture) are probably the most persistent.

(4) Since size of panicle and size of seed are correlated in a general way with width of leaf (and narrow leaves are themselves undesirable), and since small seeds do not give rise to established seedlings as generously as do large seeds, it is evident that persistency (as a character in itself) can be achieved at too high a price.

(5) Persistency is also affected by the yielding ability of the particular strain between different cuttings or grazings. The greater the yield (at the beginning) between each grazing or cutting, by that much the less the persistency. The power of recovery of the Danish strain (at the beginning) is very great, and in this fact lies another reason for its poor persistency.

(6) Yield (currently considered) is essential whether we think in terms of hay or of pasture; on this score also persistency can be achieved too dearly.

(7) From the foregoing facts it would follow that if reasonably good persistency can be attained to in a strain having broad leaves, comparatively large seeds, an erect or moderately erect habit and starting growth not too late in the spring, a strain embodying such characteristics would come near to our ideal. A compromise is essential, as the plant breeder will never be able to aggregate every desirable characteristic in a single strain. Looked at from this point of view the results so far given by our dense-hay strains with good first harvest year yields and persistency of an altogether higher order than that displayed by Danish are of great promise. It is not unlikely that in fertile soils such strains may prove to be superior to the essentially "pasture" strains even for grazing leys.

(8) A striking feature of our trials has been the excellent persistency of the pasture and pasture-hay strains on infertile soils and at high elevations, and for such purposes the extreme "Leicestershire" strain may have a special application.

(9) Erectness of growth and breadth of leaf both favouring palatability, it follows that speaking generally Danish cocksfoot is more palatable than the generality of the indigenous strains. Palatability is, however, much a matter of growth-stage, and

consequently if Danish cocksfoot is undergrazed it will assume an unpalatable condition more rapidly than the slower growing strains, while late in the season, because the indigenous strains do not show burn as soon as Danish, the former are the more palatable. Palatability is also relative; thus because stock when offered both indigenous and Danish cocksfoot in separate blocks, especially early in the year, favour the Danish, that is not to say that the indigenous strains are definitely unpalatable and would be neglected in the absence of the more palatable Danish. When the whole of a field has been sown with a single mixture in which all the cocksfoot has been represented by an indigenous strain such cocksfoot has been well grazed.

(10) Since the pedigree strains are more profusely tillering than the Danish they tend to exert a greater competitive influence on other low growing and persistent elements in a developing sward. The contribution of bent grasses and of wild white clover is therefore usually considerably lower under pedigree leafy strains of cocksfoot than under Danish. In so far as wild white clover is concerned this effect of the leafy strains is in general a decided disadvantage—a disadvantage, however, which to a large extent can be countered by hard grazing at appropriate times of the year.

(11) Evidence has been accumulated at the Station which seems to show pretty definitely that cocksfoot as a pasture grass has not the same fatting value as perennial rye-grass. The various strains of cocksfoot are, however, of great value in providing leafage at times of the year when perennial rye-grass is short, or when the rye-grass is suffering from the influences of drought.

(12) Wild white clover mingles particularly well with perennial rye-grass, and swards dominated by these two species often become excessively clovery at certain periods of the year. This leads to a ration very rich in protein and with the phosphatic-calcium ratio unduly weighted in favour of calcium. If fields sown out primarily with rye-grass—white clover mixtures had sown across them a few strips with pedigree leafy cocksfoot as the dominant grass a contrasting alternate ration would be provided for the animals which would have particular usefulness at particular times of the year. This question of alternate rations in relation to the seasonal spread-over of available herbage—in connection with which cocksfoot has a special application—is likely to become of great importance as our knowledge of the

problems underlying the intensive management of grassland increases.[2]

(13) These trials with a number of strains of one and the same species—and trials with strains of any other species would give evidence in the same general direction—raise very difficult and important questions. The different strains all tend to have their special and often ultra-local applications. Thus in the case of cocksfoot, the "Leicestershire pasture" type, although having many disadvantages, might be worth releasing and distributing primarily for poor and exacting situations on account of its profuse tillering capacity and great persistency. The ordinary Danish cocksfoot, of course, has its definite application. On fertile soils it succeeds admirably for 3-4 year leys. It should not therefore be eliminated from all seeds mixtures used in Britain unless or until a strain having all its advantages in exaggerated form and none of its disadvantages has been produced.

(14) On the balance there is perhaps everything to be said against the release of innumerable strains—no matter how excellent each may be from a special purpose point of view. It must be remembered that it is no easy matter to maintain and to distribute strains of cross-fertile grasses in a high state of purity—and to do so would demand a special organization in respect of each particular strain. Probably, therefore,—at all events until grassland farming in this country is altogether more intensified and specialized than it is at present—the plant breeder's duty is to be sparing in his dispensation of benefits, lest in his endeavour to serve local interests he engenders a state of confusion.

It has seemed desirable to touch upon this question here because it is one that will soon have to be faced and debated in detail by the interests—farmer, trade and research stations—concerned. The case of the cross-fertile herbage plants is essentially different from that of the self-fertile cereals. To a considerable extent farmers are themselves accustomed to use their own homegrown seed-corn or to obtain same within their own locality. In so far as oats are concerned it is not improbable that we want more, rather than less, special-purpose and special-condition varieties. Ultimately it should be possible to organize the seed production of herbage plants on a more localized basis, but until the seed trade and the farmer have gained sufficient experience with pedigree grasses and clovers it would, we believe,

[2] The possible advantages to be gained by managing our grasslands on a strip basis open up innumerable questions of interest. This matter will be discussed at a comparatively early date in some detail elsewhere.

be a mistake for either a research station or a progressive seed house to release or to distribute more than quite a limited number of strains of any particular species.

Acting on this belief this Station is not therefore, for example, releasing the "Leicestershire pasture" type of cocksfoot, although many years of detailed research have been devoted to it, and despite the fact that it probably has a localized application and that it has been brought to a high state of genetical purity—an altogether higher state of purity than the more general-purpose S.26 (pasture-hay strain) which has been released and is now to be regarded as a commercial commodity. The next strain to be released will be a representative of the dense-hay type—a strain which should have wide applicability and which was sown in extensive sward trials last spring.

Acknowledgments.

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THE INFLUENCE OF MANURING ON THE YIELD AND BOTANICAL COMPOSITION OF LOWLAND PASTURES:

A. UNDER CONTROLLED GRAZING BY SHEEP.
B. UNDER HAY CONDITIONS.

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Previous work carried out at Aberystwyth on this problem and reported on by Stapledon and Thomas (1) and by Davies and Jones (2) differs from the experiment discussed in this paper in

the technique used for the collection of the data. In the preliminary experiments yield data were obtained from small plots 6 ft. x 6 ft. in size which were cut monthly with shears and the herbage from the whole plot was air-dried and weighed. Thus the results were not affected by the grazing animal. In the present experiment 1/100th acre plots were used and sheep were introduced as defoliators instead of shears. The experiment was carried out at two centres, namely :—

Centre A. On a good lowland permanent pasture.

Centre B : On a five-year old ley composed mainly of perennial rye-grass and wild white clover.

The experiment under discussion was begun in the spring of 1930 and continued for two years on a monthly grazing basis. In 1931 an additional plot was fenced off from which hay and aftermath data were obtained. In 1932 all plots were allowed to grow and a hay crop was taken.

A. THE INFLUENCE OF MANURING ON THE YIELD AND BOTANICAL COMPOSITION OF LOWLAND PASTURES UNDER CONTROLLED GRAZING BY SHEEP.

Material and Methods.

At each centre a uniform block of ground was selected and on this, five 1/100th acre plots (7 yd. x 7 yd. each) were marked out and fenced off from one another, so that each plot could be treated independently. The manurial treatments (per acre) were as follows :—

Plot 1.

Complete manure (CaPKN) consisting of burnt lime 2 tons; superphosphate (16 per cent. P_2O_5) 4 cwt.; potash salts (30 per cent. K_2O) 2 cwt.; sulphate of ammonia 2 cwt. applied in the spring of 1930, followed by six subsequent monthly dressings at ½ cwt. per acre each, making a total of 5 cwt. of sulphate of ammonia per acre per annum.

Plot 2.

Complete manure as in Plot 1, excluding lime (PKN).

Plot 3.

Phosphate (P) in the form of superphosphate (16 per cent. P_2O_5) at 4 cwt. applied in the spring of 1930.

Plot 4.

Lime (Ca) applied as quicklime (CaO) 2 tons in January 1930,

Plot 5.

Control (C), no manure.

In March, 1931, a further application of superphosphate at 4 cwt.; kainit (14 per cent. K_2O) at 4 cwt., sulphate of ammonia 1 cwt., was applied to the respective plots, also the monthly applications of sulphate of ammonia at $\frac{1}{2}$ cwt. each were continued.

Data were obtained on the basis of monthly yield from May 1, 1930, to November 1, 1930; the herbage was then allowed to grow until May 1, 1931; this period constituted the winter growth. The technique was as follows:—At the end of each month a botanical analysis was made on each plot on a percentage productivity basis as used in previous experiments by Davies and Jones (2) and later by Jones (3). A pre-grazing sample was obtained by cutting 10 quadrats (1 sq. ft. each) at random on each plot. The green herbage was placed in scrim bags and air-dried to a constant weight. Sheep were then placed in each plot and the grass was grazed off as quickly as possible. The sheep were then removed and any grass not grazed was scythed off. Following this a post-grazing sample was taken, the procedure being similar to that adopted with the pre-grazing sampling. The monthly dressing of sulphate of ammonia was applied to its respective plots and the plots were then rested for a month, at the end of which time a similar procedure was again carried out.

When all the samples taken had been air-dried to a constant weight, they were weighed and the net monthly yield obtained by subtracting the weight of the post-grazing sample from the weight of the pre-grazing sample.

Discussion of Results.

It must be borne in mind that the pastures on which this experiment was carried out were already in a high state of fertility and consequently great changes in either botanical composition or yield could not be expected. The use of sheep as defoliators was an attempt to approach farm practice, in contrast to the previous experiments on this problem where grass shears were used. This attempt at carrying the experiment out under conditions similar to farm practice presented a grave difficulty. It was found that after a month's rest the growth on all plots was so great that the number of sheep necessary to graze it down as quickly as possible was far greater than the pasture carried under normal conditions. In order to ascertain the sheep carrying capacity under normal farm practice,

data were obtained for the year 1932 from the farmer at Centre B and from these data it was calculated that the pasture carried the equivalent to 5.6 sheep per acre per annum, while in the first year of the experiment it was calculated that the

TABLE I.

Showing the actual air-dry yield of each species and total yield in cwt. (= 100 lb.) per acre per season (1/6/30—30/5/31 and 1/6/31—30/5/32). Average for Centres A and B.

	CaPKN.		*PKN.*		*P.*		*Ca.*		*C*	
Species.	*1930.*	*1931.*	*1930.*	*1931.*	*1930.*	*1931.*	*1930.*	*1931.*	*1930.*	*1931.*
Perennial rye-grass ...	49.23	43.83	59.00	39.50	41.44	39.11	37.92	44.10	38.07	39.59
Rough-stalked meadow grass	5.12	10.96	3.39	5.71	2.51	7.01	2.70	8.19	2.09	2.73
Crested dogstail	1.94	1.00	1.72	0.64	1.23	1.83	1.56	1.09	1.50	0.84
Cocksfoot	1.52	7.33	0.94	3.11	1.89	3.15	0.91	1.86	1.33	2.42
Bent	2.38	0.30	2.55	1.25	3.95	3.60	2.64	0.80	3.77	2.69
Yorkshire fog	0.98	0.44	0.80	0.05	2.66	0.75	0.76	0.94	0.68	0.24
Wild white clover	1.12	0.28	0.81	0.08	2.59	0.85	2.91	0.80	3.25	0.63
Other legumes	0.08	0.02	0.06	Trace	0.03	Trace	0.12	Trace	—	Trace
Other grasses	3.58	10.14	2.98	4.20	2.70	4.36	2.07	2.17	1.61	3.58
Weeds	2.85	1.07	2.48	0.42	2.10	2.39	5.94	5.39	6.76	5.22
Moss and inert matter	0.71	0.66	0.88	0.71	0.72	0.96	0.73	0.86	0.97	0.79
Total yield per annum	69.51	75.48	75.56	55.67	61.82	64.01	58.26	66.20	59.98	58.78

number of sheep used was equivalent to 50 sheep per acre per annum. It is not supposed for one moment that the pasture under the condition of the experiment carried ten times more stock than under normal farm conditions, this figure is merely shown to illustrate the excessive stocking necessary to clip off a month's growth as quickly as possible. As would be expected, this excessive stocking resulted in an open sward of a tufted nature in comparison with the close dense sward on the field in general.

Table I (page 226) shows the actual air-dry yield of each species and the total yield per season (1/6/30—30/5/31 and 1/6/31—30/5/32) in cwt. (= 100 lb.) per acre. The figures shown in this table have been calculated from the percentage productivity analysis and the monthly air-dry yields, and therefore represent the actual weight of each species.

A study of Table I shows (*a*) the effect of treatment on individual species and (*b*) the effect on total yield.

(a) The effect of treatment on individual species.

Perennial rye-grass. In the first year of the experiment this species has derived considerable benefit from the use of CaPKN and PKN. In the second year, however, it shows a considerable decrease in yield on PKN and a slight decrease on CaPKN. The application of lime has resulted in an increase in yield in the second year.

Rough-stalked meadow grass. This species is of particular interest. It shows a slight response to manures in the first year, but in the second year this response is considerably more marked under all manurial treatments. An increase in yield is also seen on control. This increase in the second year is partly due to heavy stocking which tended to open up the sward in the first season and so to create space for the spread of this species. Also the effect of giving the pasture a month's rest resulted in the development of a much stronger type of plant than that obtained after continuous grazing.

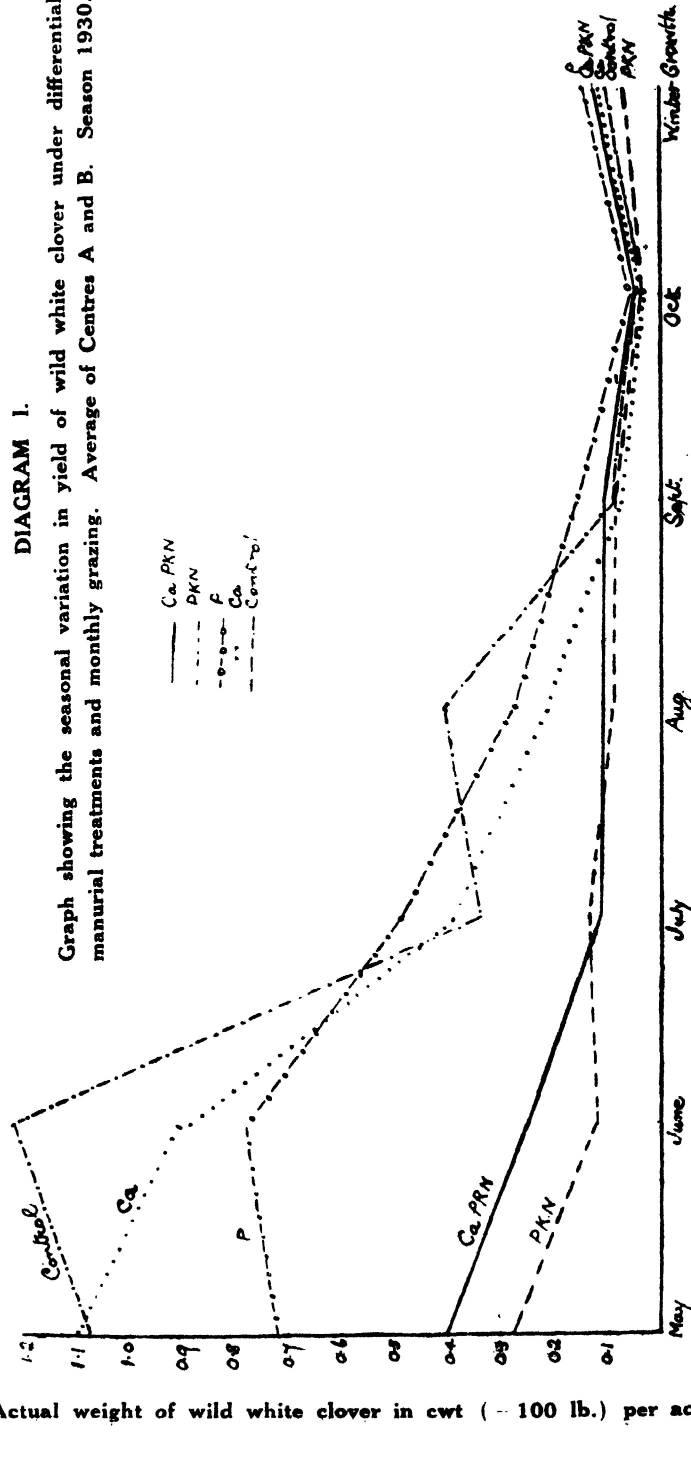
Crested dogstail. Crested dogstail did not derive any appreciable benefit from treatment.

Cocksfoot. This species, like rough-stalked meadow grass, shows an increase in yield on all plots in the second year as a result of receiving a monthly rest period. This increase, however, is greater on plots receiving treatment than on control.

Bent and Yorkshire fog. Both these species have been reduced as a result of manurial treatment except on P, where bent does not show a significant decrease. This bears out previous

DIAGRAM I.

Graph showing the seasonal variation in yield of wild white clover under differential manurial treatments and monthly grazing. Average of Centres A and B. Season 1930.



Actual weight of wild white clover in cwt (= 100 lb.) per acre,

work (2) which shows that the better grasses are increased while the poorer grasses such as bent and Yorkshire fog are reduced as a result of manurial treatment.

Wild white clover. A study of the effect of differential manuring on wild white clover in the first year of treatment shows that the actual yield is considerably less on PKN and CaPKN than on P, Ca, and C. The yield on PKN is 0.81 cwt. per acre compared with 3.25 cwt. on control. The seasonal variation in yield of this species under differential manurial treatments is shown graphically in Diagram I.

Diagram I (p. 228) shows that the bulk of the season's growth of wild white clover is produced in May, June, July and August. This is also the case in normal farm practice. Studying the effect of CaPKN and PKN, it can be seen that the yield of this species has been considerably reduced in the first month of the experiment in comparison with the yield on P, Ca, and Control, and remains at a low level throughout the season. The yield of wild white clover is much lower during the first few months of the season on the phosphate plot than on Control, but it does not exhibit such fluctuations during the later part of the season, showing a gradual decline in yield towards the autumn, while on Control there is a decided drop in yield during July, with a rise in the following month, but a further drop is shown in September. During the first month of the experiment there is a considerable response to the lime treatment, followed by a sharp decline in yield in subsequent months.

Reverting to Table I, the figures show that there is a decided drop in yield of wild white clover on all plots in the second year of the experiment, but the drop is most marked in PKN treatment, where the yield during the second year is 0.08 cwt. per acre, an amount so small as to be practically negligible. The yield on CaPKN also shows a considerable decrease. This depression of yield of wild white clover by heavy manuring plus nitrogenous manures bears out previous results (1) and (2), and further work is now in progress with a view to ascertaining the cause of this result.

Other grasses. Comparing the figures shown in Table I for "other grasses" (chiefly *Poa annua*) an increase in yield is shown for CaPKN, PKN and P in the first year. In the second year there is an increase in yield on all plots excepting Ca. As in cocksfoot, this is in part due to the monthly grazing system and heavy stocking which opened up the sward and allowed *Poa annua* to re-seed.

Weeds. Weeds have been depressed considerably as a result of treatments CaPKN, PKN, and P in the first year, and a

TABLE II.

Showing the yield in cwt. (= 100 lb.) per acre obtained from October 1 to April 30 (i.e., autumn and winter growth) in the two seasons 1930 and 1931. Average for Centres A and B.

	CaPKN.		*PKN.*		*P.*		*Ca.*		*C.*	
	1930.	*1931.*	*1930.*	*1931.*	*1930.*	*1931.*	*1930.*	*1931.*	*1930.*	*1931.*
Autumn and winter growth	18.78	26.96	22.62	15.67	16.55	21.05	18.69	19.94	15.53	15.57

further decrease is seen in the second year on CaPKN and PKN.

This depression of weeds by manuring was shown in previous work on this problem (1), (2).

(b) The effect of treatment on total yield.

Regarding the total yield in the first year, PKN gave the highest yield, but in the second year the plot had suffered so badly from sheep treading that its yield was considerably reduced. The effect of lime is evident in the second year when CaPKN and Ca show a considerable increase in yield as compared with the first year. The increased yield from the use of phosphate is not great enough to allow a pronouncement to be made on this point.

Table II (p. 230) shows the yield obtained from October 1 to April 30 in the two seasons. This period represents winter and early spring growth, and is of considerable practical importance. In the first year the figures show a considerably greater yield on PKN and CaPKN than on the other plots. In the second year the yield during this period on PKN has dropped considerably, being only equal to the yield obtained on Control. The yield from CaPKN, however, has increased, and shows a very marked increase compared with Control. P and Ca also show an increased yield during this period in the second year of treatment.

The residual effect of treatment on the hay yield in 1932.

In the third year of the experiment, namely, 1932, the plots were allowed to grow, and a hay crop was taken. No further applications of manure were given.

TABLE III.

Showing the actual yield of each species, together with the total yield in cwt. (= 100 lb.) per acre as air-dry hay. Season 1932. Average for Centres A and B.

Species.	*CaPKN.*	*PKN.*	*P.*	*Ca.*	*Control.*
Perennial rye-grass	31.27	28.46	22.11	27.95	22.75
Rough-stalked meadow-grass	11.04	10.48	5.79	12.86	8.46
Crested dogstail	0.18	0.28	0.86	0.80	0.52
Cocksfoot	3.29	7.12	8.11	3.54	2.20
Bent	1.59	5.67	6.44	2.18	4.40
Yorkshire fog	2.51	1.28	2.26	2.38	2.42
Wild white clover	Trace	Trace.	0.11	0.28	0.22
Other legumes	—	—	—	—	—
Other grasses	2.24	1.45	0.78	1.11	0.50
Weeds	Trace	0.15	0.36	0.12	0.38
Moss and inert matter	0.58	0.50	0.47	0.52	0.42
Total	52.60	50.39	47.29	51.69	42.22

Table III shows the actual yield of each species, together with the total yield in cwt. per acre as air-dry hay in the third year of the experiment.

Effect of treatment on species.

Perennial rye-grass. This species derived considerable benefit from CaPKN and Ca treatments, suggesting that the use of lime has had a beneficial effect.

Rough-stalked meadow-grass. This species shows a greater yield on CaPKN, PKN, and Ca than on Control, while the yield on P is less than on Control.

Cocksfoot. Cocksfoot shows a higher yield on PKN and P than on CaPKN, Ca, and Control. The relatively low yield of this species on CaPKN is probably due to the effect of competition with perennial rye-grass.

Bent. This species has been reduced on CaPKN and Ca.

Wild white clover. The effect of CaPKN and PKN is very marked, only traces of this species being present.

Effect on total yield.

The residual effect of the manurial treatments is very marked under hay conditions. The yield on CaPKN is 10.38 cwt. greater than that produced on Control. Of the manurial treatments CaPKN and Ca produce the greatest response, followed closely by PKN.

B. THE EFFECT OF MANURING ON THE YIELD AND BOTANICAL COMPOSITION UNDER HAY CONDITIONS.

For this purpose a plot 1/100th acre in size was fenced off in 1931, adjacent to the plots already discussed; half this area was manured with :—

CaPKN	CaO 2 tons Superphosphate 4 cwt. Kainit 2¼ cwt. Sulphate of ammonia 1 cwt.	per acre.

This was applied in March, 1931. A further application of sulphate of ammonia was given after a hay crop had been taken; the remaining half was unmanured. The plots were cut for hay and aftermath.

Material and Method.

On each plot two quadrats 6 ft. x 6 ft. each were cut and weighed green. A 2 lb. sample was taken and air-dried, from which the air-dry weight of the plot was calculated; also a 1 lb.

sample was taken and botanically analysed. This technique was carried out for both hay and aftermath.

Discussion of Results.

From the total air-dry yield and the botanical analysis the actual yield of each species as hay and aftermath was calculated, and the figures obtained are shown in Table IV.

TABLE IV.

Showing the air-dry yield in cwt. (= 100 lb.) per acre of hay + aftermath of each species and also the total yield. Season 1931. Average of Centres A and B.

	Perennial rye-grass.	*Rough-stalked meadow grass.*	*Crested dogstail.*	*Cocksfoot.*	*Bent.*	*Yorkshire fog.*	*Wild white clover.*	*Other grasses.*	*Weeds.*	*Moss and inert matter*	*Total yield.*
CaPKN	43.16	17.43	1.58	6.26	15.93	12.26	0.68	5.52	1.39	0.22	104.43
Control	37.87	8.79	2.70	6.06	28.93	11.89	2.80	1.79	3.24	0.81	99.88

Studying the effect of treatment on the actual yield of the species, it can be seen that perennial rye-grass, rough-stalked meadow grass and " other grasses " (chiefly fine-leaved fescue) have derived benefit from the complete manurial treatment, while bent and weeds have been depressed.

Regarding the effect of treatment on total yield, a slight increase in yield is seen on CaPKN compared with the yield on Control.

The point of main interest in Table IV is the exceptionally high total yields obtained on both plots illustrating the high state of fertility of the lowland pasture on which the experiment was carried out. This yield of air-dry herbage is equivalent to a yield of 30 tons of roots per acre, and shows (although this fact is not generally recognised by farmers) that grassland, if managed efficiently, is capable of giving an enormous yield of fodder. The experiment was carried out in the second year, but owing to the high yield on CaPKN the crop lodged badly, and accurate weights could not be taken.

Summary and Conclusions.

The high yielding capacity of good lowland pastures, even without further manuring, has been illustrated. This fact makes experimental work using sheep as defoliators on small plots extremely difficult on account of the heavy stocking necessary to control the grazing. However, the results obtained illustrate that pastures, even when in a high state of fertility, derive benefit from manurial treatment, as shown by the increase in perennial rye-grass and rough-stalked meadow grass and by the decrease in the contribution of bent, Yorkshire fog, and weeds. The beneficial effect of lime on grassland has been shown, a fact which has been observed by many practical farmers. As shown in previous experiments (1), (2), wild white clover has been depressed by nitrogenous manuring.

Acknowledgments.

I desire to express my gratitude to Professor R. G. Stapledon, C.B.E., M.A., for his helpful interest and advice. Thanks are also due to Mr. J. M. Edwards, Nantsiriol, Bow Street, Cardiganshire, and Mr. J. Ivor Williams, Llanfarian, near Aberystwyth, on whose farms the experiment was carried out, for their generous assistance.

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THE USE OF A CULTURE INOCULANT FOR CLOVER.

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Introduction.

Following on evidence of a deficiency of the clover nodule organism on some Welsh hill soils (Poulter, 1933), trials with different strains of the organism were set up in 1933. The cultures were supplied by Dr. H. G. Thornton, and included strains from abroad as well as strains isolated by him from selected local soils.

Whilst the evidence is as yet incomplete, it is sufficiently significant for a preliminary report, bearing in mind the practical advantages to be obtained by using a culture as opposed to a soil inoculant.

The Trials.

The trials were set up at three different hill centres on ploughed, virgin grass land. On Coryn Land and Plynlimon (Poulter, 1933) the same six cultures were used, whilst at Pwllpeiran, Cardiganshire, two of these were used, together with four local strains.

The inoculated wild white clover seed at 10 lb. per acre was superimposed on a seeds mixture already harrowed in and phosphatically manured, and was covered by means of a hand rake. The plots were each 1/100th acre, separated from each other by two yard strips, and were replicated three times.

At Pwllpeiran the experiment failed entirely on freshly ploughed bent-fescue land, owing to the drought and the late sowing. In spite of this, some evidence was obtained from a very

wet *Molinia* marsh, which never completely dried out during the season. Unfortunately, there was not sufficient area for the plots to be either replicated or separated from each other by any distance.

TABLE I.

Comparison of nodulation induced by different strains of *Bac. radicicola*, Strain Barthel C placed at 100.

75 or more plants examined in each case.

Culture.	*Area.*		
	Pwll-peiran.	*Coryn.*	*Plynlimon.*
Wisconsin 200	9.3	9.5	27.2
Wisconsin 209	—	21.4	22.1
Barthel A	—	158	126
Barthel B	--	14.3	28.9
Barthel C	100	100	100
Barthel R	--	16.7	14.4
Coryn	201	—	—
Frongoch	94	—	—
Nant-y-gwrdi	86	—	—
Tan-y-bwlch	65	—	—
Soil (Frongoch)	188	91	—
Soil (Nant-y-gwrdi)	—	—	49
Control	17	0.5	3.6

TABLE II.

Establishment* data for wild white clover, Plynlimon, 1933. Sown May 19, 1933. Analysed October 21, 1933, by means of 6 x 6 in. mesh. 60 readings per culture = 20 readings per 1/100th acre plot replicated 3 times.

Culture.	*Total No. of plants.*	*Relative value Barthel C at 100.*	*Per cent. "puny" plants in total‡.*
Wisconsin 200	37	12.4	46
Wisconsin 209	61	7.0	60.6
Barthel A	105	120	8.6
Barthel B	45	58	69
Barthel C	87	100	26.5
Barthel R	28	26.5	47.8
Soil (Nant-y-gwrdi)	48	55	56.2
Control	46	53	67.4

* Observations on plant size at the time of sampling for nodule counts on July 29 promised greater differences between cultures, had it been a normal year instead of the prolonged drought.

‡ "Puny" plants are distinguished arbitrarily by minute size and unhealthy colour.

Evidence.

The evidence of relative success of the cultures depends on evidence from nodulation counts (Table I) and from establishment data (Table II). These latter are only available for Plynlimon.

Discussion.

There is sufficient evidence to show that the failure of the culture used in 1932 (Poulter, 1933) was due to the unsuitability of the bacterial strain used. Inoculation by culture promises future success, so that the practical difficulties of carriage and labour costs involved in soil inoculation are eliminated.

Summary.

1. Evidence is given of increased nodulation of wild white clover induced by culture inoculants.

2. Different strains of the nodule organism differed in their ability to induce nodulation.

3. These differences were consistent at different centres and were correlated with expected differences in vigour and establishment.

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THE PERSISTENCY OF VARIOUS GRASSES AND CLOVERS WHEN SOWN IN PURE PLOTS AND IN MIXTURES ON PEAT LAND.

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Introduction.

A considerable amount of evidence in connection with the problem of laying down peat land to grass has been collected in Merionethshire and reported on by Griffith (1). This evidence related to an experiment laid down in 1923 on the farm of Mr. Roberts, Cefn Uchaf, Waun, Bala, at an altitude of 950 feet. The object of the experiment was to test the establishment of various grasses and clovers when sown in pure plots and in mixtures on reclaimed peat land in order to obtain information which would be of service to the practical farmer. The problem of laying down peat land to a good permanent pasture is acknowledged to be a difficult one, and it was found that farmers were loath to spend money on a seeds mixture, preferring to sow hay loft seeds on this type of soil.

The report published by Griffith (1) dealt with data collected in the years 1923, 1924 and 1925. The present paper is concerned with data collected in subsequent years (up to 1932) on the same experiment with a view to ascertaining the persistency of the grasses and clovers.

Material and Methods.

An application of 12 tons per acre of farmyard manure was given to the 1922 crop (potatoes and roots). In April, 1923, two months before the experiment was started, a dressing of 3 cwt. per acre of Nauru phosphate and 8 cwt. per acre ground limestone was applied, while the young seeds were dressed with 5 cwt. per acre of basic slag in November of the same year.

The mixtures were laid down in plots 7 yards × 30 yards (1/40th acre) and the pure plots were 7½ yards × 4 yards (1/160th acre) in 1923; no nurse crop was used. A hay crop was taken each year from 1923 to 1927. The aftermath was grazed by cattle up to October in each year; from November to May the plots were heavily grazed by mountain sheep. From 1927 to 1932 the plots during each summer period were grazed by

cattle; during each winter period they were heavily grazed by mountain sheep. As stated above, data for the years 1923 to 1925 have already been reported on (1). Notes were taken in the years 1926 and 1927. In 1932 a detailed botanical analysis was made on a percentage tiller estimation basis with counts of tillers of sown species, also a percentage estimation of the ground covered by sown species, unsown grasses, clovers, weeds, moss and bare ground was made.

Discussion of Results.

1. *The persistency of species sown in pure plots.* Table I is taken from the report by Griffith (1) and shows the species sown and the results obtained in the years 1923 to 1925.

TABLE I.

Showing the species sown in pure plots, together with marks awarded for purity and density for the years 1923, 1924 and 1925; also green weight of hay per plot for the years 1924 and 1925.

Species.	*Seeds sown (lb. per acre).*	*Purity and density marks awarded. Maximum = 100.*			*Green weight of hay per plot (in lb.)*	
		1923	*1924*	*1925*	*1924*	*1925*
1. Perennial rye-grass	25	90	80	50	98	48
2. Cocksfoot (commercial)	25	95	80	10	100	46
3. Cocksfoot (indigenous)	25	90	85	65	105	28
4. Timothy	15	95	95	90	167	90
5. Meadow fescue	25	50	70	50	125	38
6. Tall fescue (indigenous)	30	15	50	10	120	52
7. Meadow foxtail (commercial)	30	85	70	70	76	68
8. Meadow foxtail (indigenous)	30	90	80	80	73	68
9. Crested dogstail	20	70	70	30	113	42
10. Rough-stalked meadow-grass	10	85	70	65	87	42
11. Smooth-stalked meadow grass	10	25	55	45	72	36
12. Alsike (English)	10	75	70	0	112	—
13. Alsike (Swedish)	10	80	75	0	127	—
14. Red clover (wild)	15	50	55	15	112	—
15. Red clover (Montgomery)	15	80	80	0	125	—
16. Red clover (Vale of Clwyd)	15	70	60	0	112	—
17. Red clover (Chilean) ...	15	40	7	0	—*	—
18. White clover (wild)	8	70	85	40	100	—
19. White clover (Dutch) ...	8	80	65	0	107	—
20. *Lotus corniculatus* ...	10	70	10	0	—*	—
21. *Lotus angustissimus*	8	20	0	0	—*	—
22. *Lotus major*	8	40	5	0	*	—
23. Subterranean clover	10	90	0	0	—*	—
24. Strawberry clover	8	35	5	0	—*	—
25. Yellow suckling clover	8	75	0	0	—*	—
26. Lucerne	20	20	2	0	—*	—
27. Hubam clover (*Melilot*)	15	65	0	0	—	—

*The sown species were represented by only a few plants on each of these plots.

A study of Table I shows that all the grasses had persisted in varying degrees up to 1925, whereas the only clover which persisted into the second year was wild white clover; there was also a trace of wild red clover. The marked decrease in hay yield in the second harvest year is to a great extent due to late grazing by sheep followed by a period of drought.

TABLE II.

Showing marks allocated for purity and density of sward in 1926 and 1927.

Species.	*1926*	*1927*
1. Perennial rye-grass	40	85
2. Cocksfoot (commercial)	20	5
3. Cocksfoot (indigenous)	55	50
4. Timothy	85	70
5. Meadow fescue	20	10
6. Tall fescue (indigenous)	15	35
7. Meadow foxtail (commercial)	50	80
8. Meadow foxtail (indigenous)	65	60
9. Crested dogstail	50	55
10. Rough-stalked meadow grass	40	40
11. Smooth-stalked meadow grass	40	35
12. Wild white clover	40	40

Table II shows the marks allocated in 1926 and 1927 for purity and density of the sward. It is seen that by the fourth harvest year commercial cocksfoot has decreased and covers only about 5 per cent. of the ground, while indigenous cocksfoot covers about 50 per cent. This difference between indigenous and commercial strains of the same species in regard to persistency is seen again in meadow foxtail : the figures show that by the fourth harvest year commercial meadow foxtail covers 30 per cent., while the indigenous strain covers 60 per cent. of the ground. Timothy seems to have persisted to the greatest extent, but perennial rye-grass, tall fescue, crested dogstail, rough-stalked meadow grass, smooth-stalked meadow grass and wild white clover, though not as good as timothy, have persisted into the fourth harvest year in fair amounts.

Data obtained in the ninth harvest year are presented in Table III. The figures of the percentage tiller estimation show that rough-stalked meadow grass, crested dogstail, indigenous meadow foxtail and wild white clover have persisted into the ninth harvest year in quite appreciable amounts, also that indigenous cocksfoot, indigenous tall fescue and meadow fescue

TABLE III.

Showing (a) actual counts of tillers per 10 mesh (6 in. × 6 in.) readings; (b) the percentage tiller estimation; (c) total tillers per 10 mesh (6in. × 6 in.) readings; and (d) an estimation of ground covered by sown species, other grasses, other legumes, weeds, bare ground and moss. Analysed 1932.

Species.	(a)	(b) Percentage tiller estimation				(c)	(d) Percentage ground covered.				
	No. tillers of sown species.	*Sown species.*	*Other grasses.*	*White clover + legumes.*	*Weeds.*	*Total tillers per 10 mesh (6in. × 6in.) readings.*	*Sown species.*	*Other grasses.*	*Other legumes.*	*Weeds.*	*Bare ground + ground covered by moss.*
Perennial rye-grass ...	27.5	2.3	91.2	0.3	6.2	3675	0.5	64.5	0.5	27.5	7.0
Cocksfoot (commercial) ...	7.0	0.2	95.2	0.5	4.0	3475	0.3	67.0	1.0	27.7	4.0
Cocksfoot (indigenous) ...	96.5	5.2	86.0	1.3	7.5	2860	1.3	56.0	2.5	29.7	7.5
Timothy	3.0	Trace	90.8	Trace	9.3	3655	Trace	61.2	Trace	34.0	4.8
Meadow fescue	39.5	2.0	79.3	3.0	15.8	2510	1.0	55.5	2.0	36.0	5.5
Tall fescue (indigenous)	51.5	2.3	83.0	4.5	10.2	3005	1.0	68.0	4.7	27.5	7.8
Meadow foxtail (commercial)	13.5	0.5	80.3	4.3	15.0	2405	0.5	56.2	4.2	35.0	4.1
Meadow foxtail (indigenous)	183.0	11.0	68.0	1.3	19.8	1815	4.3	45.0	0.5	44.5	5.7
Crested dogstail ...	236.0	13.0	61.0	11.5	14.5	1820	6.5	38.5	18.0	31.5	5.5
Rough-stalked meadow grass	227.0	14.5	46.5	17.0	22.0	1490	1.5	24.0	20.5	40.0	11.0
Smooth-stalked meadow grass	1.0	Trace	83.0	5.0	12.0	2090	Trace	54.0	4.0	36.0	6.0
Wild white clover	231.5	11.5	82.2	--	6.8	2380	19.0	57.0	—	20.0	4.0

have persisted in slightly smaller amounts. Timothy, commercial cocksfoot, commercial meadow foxtail and smooth-stalked meadow grass are practically non-existent. Perennial rye-grass, though poor, has persisted in a very small degree into the ninth harvest year. This evidence is corroborated by the data obtained on the basis of ground covered by sown species, etc. The figures shown in column (a) represent actual counts of tillers of sown species per 10 mesh readings (6 in. × 6 in.). These figures are shown in Table IV as relative figures with crested dogstail placed at 100.

TABLE IV.

Showing the relative number of tillers per unit area of species sown in pure plots relative to crested dogstail at 100. (Analysed in 1932).

Crested dogstail.	*Wild white clover.*	*Rough-stalked m'dow grass*	*Meadow foxtail (ind.).*	*Cocksfoot (ind.).*	*Tall fescue (ind.).*	*Meadow fescue.*	*Perennial rye-grass.*	*Meadow foxtail (com.).*	*Cocksfoot (com.).*	*Timothy.*	*Smooth stalked m'dow grass.*
100.0	98.1	96.2	77.5	40.1	21.8	16.7	10.7	5.7	3.0	1.3	0.4

It is seen from Table IV that crested dogstail, wild white clover and rough-stalked meadow grass have the highest persistency, followed closely by indigenous meadow foxtail. Indigenous cocksfoot shows far greater persistency than commercial cocksfoot, the latter, with timothy, smooth-stalked meadow grass and commercial meadow foxtail, having practically died out. Tall fescue and meadow fescue have persisted to a greater degree than perennial rye-grass.

2. *The persistency of species sown in mixtures.* Table V has been extracted from the report by Griffith (1) and shows the mixtures used and the air-dry yields of hay in 1924 and 1925.

A detailed botanical analysis was made in 1982, the results of which are shown in Tables VI and VII. As shown in the pure plots all clovers tested, with the exception of wild white clover, had died out by the second year. This was the case also in the mixtures, so that the results obtained from Plots A 1, 2, 4 and 6 have been averaged, since the only difference in the mixtures used in this series was a difference in clover. Similarly Plots B 1, 2 and 4 have been averaged, also D 1 (a) and 1 (b). Table VI shows the actual counts of tillers per 10 mesh readings (6 in. × 6 in.) of sown species.

TABLE V.

Showing seeds mixtures tested and the air-dry yields of hay per plot in 1924 and 1925.

Plot. No.	*Basal Mixture.*	*Species.*	*Seed per acre (in lb.)*	*Hay per plot.* 1924.	*Hay per plot.* 1925.
A. 1	Timothy 12 lb. per acre; crested dogstail 4 lb. per acre.	Plus Montgomery red clover	7½	127.86	84.32
A. 2		Plus Alsike	5	132.36	86.94
A. 3		Plus Wild white clover	4	130.06	75.25
A. 4		Plus Subteranean clover	2	127.26	68.42
A. 5		Plus *Lotus angustissimus*	4	119.08	61.18
A. 6		Plus *Lotus major*	4	127.18	65.61
B. 1	Cocksfoot 9 lb. per acre; perennial rye-grass 9 lb. per acre.	Plus Montgomery red clover	7½	130.51	59.73
B. 2		Plus Alsike	5	136.43	56.61
B. 3		Plus Wild white clover	4	130.91	64.16
B. 4		Plus Subteranean clover	2	133.49	29.44
C. 1		Meadow foxtail	9		
		Meadow fescue	9	148.51	52.68
		Montgomery red clover	7½		
D. 1		Fiorin (commercial)	8		
		Chewing's fescue	8	116.86	48.28
		Montgomery red clover	4		
		Wild white clover	2		
D. 1 (b)		As D.1, plus *Bromus Schraderi*	12	120.43	67.27
D. 2		Perennial rye-grass	8		
		Crested dogstail	4		
		Rough-stalked meadow grass	4	127.32	72.77
		Montgomery red clover	4		
		Wild white clover	2		
D. 3		As D.2, but with smooth-stalked meadow grass instead of rough-stalked meadow grass	4	113.35	49.21
		Tall oat grass	4		
		Phalaris bulbosa	4	131.44	38.18
		Montgomery red clover	4		
		Wild white clover	2		
D. 5		Perennial rye-grass	12	112.90	29.07
		Wild white clover	4		
D. 6		Montgomery red clover	4		
		Alsike	2½		
		Subterannean clover	2	142.01	0.00
		Lotus angustissimus	2		
		Lotus major	2		
		Yellow suckling clover	2		

TABLE VI.

Showing counts of tillers per 10 mesh readings (6in. x 6 in.) of sown species. (Analysed in 1932).

	Perennial rye-grass.	*Cocksfoot.*	*Timothy.*	*Meadow fescue.*	*Meadow foxtail.*	*Crested dogstail.*	*Rough-stalked meadow grass.*	*Wild white clover.*
A. 1, 2, 4, 5, 6 ..	—	—	5.2	—	—	158.0	+	—
A. 3	—	—	3.0	—	—	—	—	158.5
B. 1, 2, 4	12.3	0.7	—	—	—	—	—	—
B. 3	29.1	21.0	—	—	—	—	—	151.0
C. 1	—	—	—	27.5	3.0	—	—	—
D. 1 (*a*); 1 (*b*) ...	—	—	—	—	—	—	—	176.2
D. 2 ...	6.5	—	—	—	—	125.1	117.5	195.0
D. 4 ..	1.0	—	—	—	—	—	—	127.0
D. 5	—	—	—	—	—	—	—	146.0
D. 6	—	—	—	—	—	—	—	—

A study of Table VI shows that wild white clover has done exceptionally well, followed closely by crested dogstail and rough-stalked meadow grass. This was also the case when these species were sown in pure plots. A comparison of Plot B 3 and an average of Plots B 1, 2 and 4 is of interest in that on Plot B 3 where wild white clover was included in the mixture there are considerably more tillers of perennial rye-grass and cocksfoot than on Plots 1, 2 and 4 where these species have been sown without wild white clover, but with Montgomery red clover, alsike and subterranean clover respectively. Timothy and commercial meadow foxtail are practically failures from the point of view of persistency; meadow fescue also has given poor results.

In Table VII data relating to the analysis based on a percentage tiller estimation and an estimation of total tillers per 10 mesh readings (6 in. × 6 in.) of the sward as a whole are presented.

Table VII shows that Plot D 6, which is a mixture composed of Montgomery red clover, alsike, subterranean clover, *Lotus angustissimus*, *L. major* and yellow suckling clover, is a complete failure, none of the sown species having survived. Plots on which the mixture sown contains wild white clover, crested dogs-tail and rough-stalked meadow grass, either alone or in combination, have a considerably higher percentage of sown species than any of the other plots, except Plot D 1 (a) and 1 (b). In the latter plots a mixture of bent, Chewing's fescue and wild white clover was sown. The figures for this mixture show that Chewing's fescue and wild white clover had done very well,

TABLE VII.

Showing the percentage tiller estimation and estimation of total tillers per 10 mesh readings (6 in. x 6 in.) (Analysed in 1932).

	Sown species.	*Bent.*	*Fine-leaved fescue.*	*Wild white clover.*	*Other grasses.*	*Other legumes.*	*Weeds.*	*Total tillers per 10 mesh readings.*
A. 1, 2, 4, 5, 6 ...	8.0	48.6	6.2	3.1	22.4	-	7.7	2640
A. 8	13.5	46.2	—	—†	32.3	-	8.0	2125
B. 1, 2, 4	0.3	64.0	8.8	2.2	17.8	0.2	6.7	3193
B. 3	9.5	65.5	2.0	—†	12.0	—	11.0	2150
C. 1	1.5	26.8	31.7	4.5	22.0		10.5	2410
D. 1 (*a*); 1 (*b*) .. .	6.8	29.1*	39.7*	—†	18.1		6.3	2890
D. 2	20.2	56.2	9.3	—†	7.8	—	6.5	2370
D. 4	8.5	57.5	12.0	—†	21.5	·	5.5	3470
D. 5 . .	4.0	74.0	1.0	—†	18.5	--	2.5	3550
D. 6	—	68.0	1.0	3.5	13.5	·	14.0	3460

* Sown species.
† Included in sown species column.

Bent, however, does not show a high percentage when compared with the amounts present on other plots where it was unsown and it appears to have been suppressed very considerably by Chewing's fescue. The high figure for Chewing's fescue on Plot C 1 is to be explained by the fact that this plot is adjacent to the previous plots, and though Chewing's fescue is, as a rule, spot bound, it has encroached on this plot from Plot D 1 (a), probably by re-seeding itself.

Summary.

In discussing the final result of the experiment an important point to be considered is the general management of the plots. As stated, the plots were mown for hay up to the fifth harvest year, and after each hay crop the aftermath was grazed off by cattle, followed by very heavy grazing during the winter months by sheep. In subsequent harvest years the plots were grazed during the summer period by cattle, followed by heavy grazing in the winter months by sheep. As peat soil is inclined to be of a friable nature, it is evident that this treatment is very drastic, and a considerable number of plants are likely to be pulled up by the roots. In spite of this severe treatment, however, many of the species sown have given good results. Judging from the data obtained from this experiment, crested dogstail, rough-stalked meadow grass, Chewing's fescue and wild white clover have given the best results over a long period of years (9 years) on reclaimed peat land. However, it is of considerable significance

to note the greater persisting ability of indigenous meadow foxtail and indigenous cocksfoot compared with the commercial strains of these two species.

Conclusions.

When the experiment discussed in this paper was begun, supplies of indigenous strains of grasses were very limited and the only indigenous strains used were those of cocksfoot, tall fescue and meadow foxtail. The results show that in the early part of the experiment commercial strains compare favourably with indigenous strains. As the experiment progressed, the superiority of these indigenous strains became very marked. Perennial ryegrass has given very poor results, but, bearing the previous statement in mind, it is highly probable that some of the indigenous strains of this species, which have been evolved in recent years, may prove more suitable for peat land than the commercial strain used in the experiment. Bent, as an unsown species, has proved a very rapid colonizer of the ground. This has been useful on plots where the sown species died out in the early years of the experiment, but where it is possible to establish better grasses the use of bent as a component of seeds mixtures for peat land is not recommended.

Acknowledgments.

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REFERENCE.

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PASTURE MANAGEMENT AND ITS EFFECT ON THE SWARD.

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The investigation of pasture problems in the past has been centred mainly around seeds mixtures and manures. It was realised, however, that extremes in management had an effect on the botanical composition of the sward. As an instance of

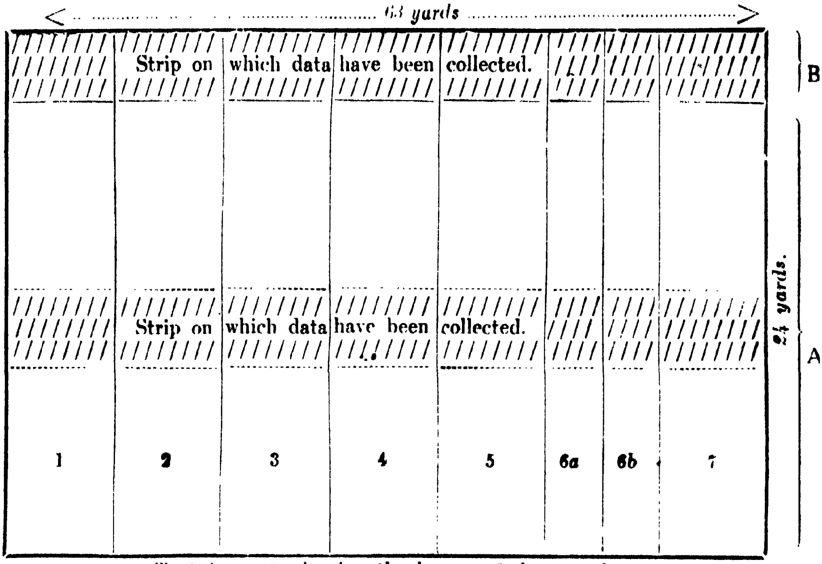
this it has often been shown that the two grasses tall oat grass and tall fescue are never found in abundance on any well grazed permanent pasture, whereas they are plentiful on the adjoining roadsides and on ungrazed or undergrazed waste corners of the fields. In recent years a number of investigators (1), (2), and (3) have made interesting observations on the effect of the grazing animal on the type of sward produced. Experiments carried out at the Welsh Plant Breeding Station have also thrown light on this question.

Stapledon (4) has shown that under artificial grazing of single plants certain species such as cocksfoot, tall oat grass and tall fescue were considerably weakened by a series of cuts, whereas other species such as perennial rye-grass and crested dogstail were far less sensitive. It was also shown that repeated cutting reduced the root system of grasses to a small percentage of that developed under a lenient system of cutting. Later work (5) and (6), when sheep were used as the grazing animals, showed that the grazing management had a considerable effect on the botanical composition of the sward, and that under a system of continuous grazing, cocksfoot, particularly commercial strains, Italian rye-grass and timothy were greatly reduced in the pasture, while bent, white clover and the various weeds increased considerably. Fenton (7) found that a sward where bent was the dominant species under the old system of inadequate grazing was changed into a perennial rye-grass dominant pasture under a system of sectional grazing and manuring. During the last year a number of papers have been published (8; 9) showing how pastures are influenced by different methods of management, and how it is possible to change a grassy sward into a clovery sward, and *vice versa*.

As a result of observations made, together with the earlier data collected at the Welsh Plant Breeding Station, it was decided in the summer of 1929 to lay out an experiment on an outrun ley designed solely to test the influence of the grazing animal on the pasture. Following this, a standard experiment was set up in the early spring of 1930 on six different types of grassland, two on rushy swards (one of which is a genuine marsh), one on an outrun ley, another on a young ley consisting of several types of seeds mixtures together with a *Molinia* and also a bent-fescue sward in the hills. The present article embodies the results obtained from the area which was first laid out for this purpose.

Material and methods.

In July, 1929, an area of grassland measuring 24 yards x 63 yards was divided into seven plots, each measuring 24 yards x 9 yards; one of these was divided later into two sub-plots, 6*a* and 6*b* (see plan).



Text-figure 1, showing the layout of the experiment.

The area consisted of two types of sward arranged as follows :—

(1) The main area A, 20 yards x 63 yards, was derived from a seeds mixture sown in 1923.

(2) A narrow strip B, 4 yards x 63 yards, was sown in 1926 as a headland mixture of another experiment.

By 1929, however, most of the original species had disappeared in both, and the sward consisted of :—

	A.	*B.*
	per cent.	
Bent	65	45
Yorkshire fog	15	15
Rough-stalked meadow-grass	7	12
Sweet vernal	4	1
Tall fescue	4	—
Cocksfoot	Trace	6
Festuca rubra	Trace	9
White clover	3	2
Weeds	2	7

A hay crop had been taken from this area every year since it had been sown, and very little grazing had been allowed on it. In 1929 the hay crop was taken in June and the experiment was started three weeks after its removal.

The plan of management adopted for the various plots was as follows :—

Plot 1. Grazed every two months[1]—*undergrazing.*

Plot 2. Grazed every month—*medium grazing.*

Plot 3. Grazed every week in spring,[2] and every month in summer and autumn—*hard spring grazing.*

Plot 4. Grazed every week (spring, summer and autumn) —*hard grazing.*

Plot 5. Grazed every week in autumn,[2] and every month in spring and summer—*hard autumn grazing.*

Plot 6. Cut with the scythe every two months at the same time as Plot 1 is grazed. This plot was sub-divided into :—

Plot 6*a*. Scythed herbage removed from plot.

Plot 6*b*. Scythed herbage allowed to rot on plot.

Plot 7. Control. This plot was neither grazed nor cut.

Method of grazing.

The grazing was carried out through the whole period by means of tethered sheep.[3] The aim was to induce the sheep to eat as much as possible of the food offered at each grazing, thus they were allowed to graze for a longer period of time on the plots which had a good growth of herbage. This was made possible by giving them a shorter length of new herbage every time they were shifted.

On Plot 4 a pair of sheep grazed for 2½-3½ days every week, starting at the bottom every Friday and being shifted twice a day two or three yards, according to the amount of fodder available. It was also arranged that if they started Plot 4 on Friday morning of one week they started there again on the evening of the following week. In spring the sheep grazed Plot 3 as soon as they had finished Plot 4, while in the autumn they grazed Plot 5 after Plot 4 every week. The rest of the week was spent grazing the other plots according to schedule. During the greater part of the grazing season the grazing on all plots was carried out by one pair of sheep, but occasionally an additional pair was brought on to the area in order to keep to schedule.

Intensity of Grazing.

The intensity of the grazing is indicated in the following statement, which shows the average number of days per acre that

---

1 The grazing season usually extended from mid-April to mid-October.

2 For the purpose of this experiment spring extended from mid-April to mid-June and autumn extended from mid-August to mid-October.

3 For a detailed description of the method of grazing by tethered sheep see *Welsh Plant Breeding Station Bulletin* (Series H), No. 13, p. 97. 1932.

sheep grazed on each of the plots for the three periods of the grazing season.

Period.	*Number of sheep days per acre.* Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.
Spring (April 15—June 15) ...	315	525	1170	1148	368
Summer (June 16—August 15)	315	315	360	1035	405
Autumn (August 16—October 15)	360	485	430	1215	1225

The above figures include the summer and autumn grazing periods of 1929 and the whole of the grazing seasons of 1930, 1931, and 1932.

The number of sheep used on the hard grazed area (Plot 4) is equivalent to a stocking of about eighteen sheep per acre during the six months. The area grazed hard in the spring (Plot 3) and that grazed hard in the autumn (Plot 5) also had a stocking of about eighteen sheep per acre during their respective hard grazing periods, whereas during the rest of the grazing period they were stocked at about the same intensity as the plot grazed every month; this was equivalent to about seven sheep per acre. The stocking on the plots grazed every two months was equivalent to about five and a half sheep per acre during the grazing season.

Method of collecting data.

After three and a half years of the above management it was decided to make a close study of the effect of the different treatments on the respective plots. The data were collected in 1933. For this purpose in February, 1933, each plot was fenced, leaving a strip seven feet wide across the A and B area (shaded strips in Text-figure 1). This allowed of the grazing in fenced plots of the rest of the A area during 1933 according to the original schedule, while the B area was given up entirely to the collection of data during that period. These two strips were then cut by means of shears to ground level and all the herbage was taken off the plots. The technique adopted subsequently was as follows :—

(1) Five yard quadrats were marked off on both strips on each plot and the herbage on each of these was cut every four or five weeks; these are known as the pasture cuts.

(2) Two yard quadrats were also marked off on each plot, and the herbage on these was cut as hay and aftermath.

(3) In the late autumn, turfs were dug up from these plots and counts were made of the number of tillers of each species present.

Results of the botanical analyses of the sward.

A comparison of the number of tillers of the various species present under different types of management is shown in Table I and Text-figure 2. Further details are given in Appendix I. The data for the two plots which were either grazed every week in the spring or else every week in the autumn have been omitted from Table I, and are dealt with later. The results for the two sub-plots, 6*a*, cutting every two months and removing herbage, and 6*b*, cutting every two months and allowing herbage to rot, have been averaged and are entered in Table I under the one column " mowing."

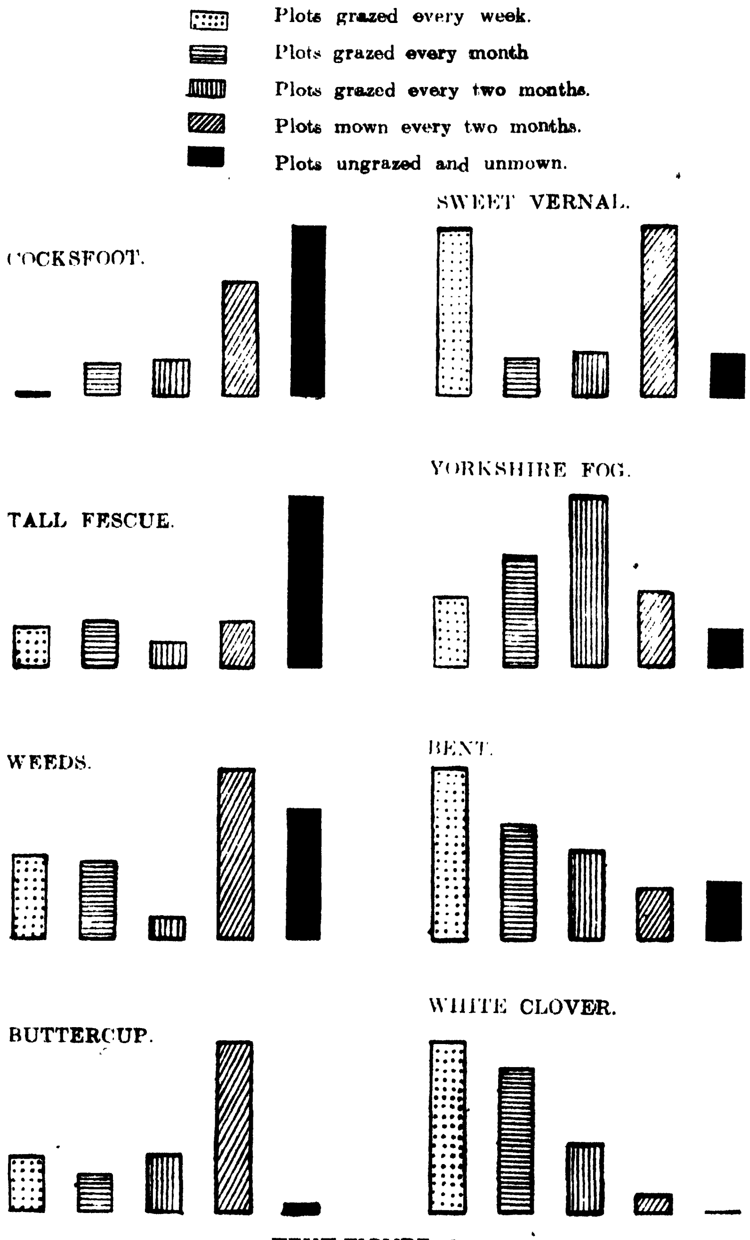
TABLE I.

Showing the relative number of tillers of certain species on the different plots in November, 1933. (The highest number of tillers for each species is placed at 100, and the numbers for the other plots are based on this).

Species.	*Plots grazed every*		
	Week.	*Month.*	*Two. Months.*
Cockstoot	1.8	19.2	20.5
Tall fescue	23.8	27.2	14.8
Weeds (excluding buttercup)	18.8	14.6	18.0
Buttercup	32.0	21.7	84.2
Sweet vernal	98.5	22.1	26.0
Yorkshire fog	11.5	66.5	100.0
Bent	100.0	66.6	51.8
White clover	100.0	83.8	40.5
Relative amount of moss ...	100.0	64.0	7.9

Species.	*Plots not grazed.*	
	Mowing.	*No mowing.*
Cocksfoot	66.6	100.0
Tall fescue	27.2	100.0
Weeds (excluding buttercup) ...	100.0	76.2
Buttercup	100.0	4.5
Sweet vernal	100.0	25.0
Yorkshire fog	44.8	23.5
Bent	29.1	34.2
White clover	11.5	0.7
Relative amount of moss ...	60.0	2.2

Table I and Text-figure 2 show that cocksfoot and tall fescue thrived best when neither grazed nor mown, that is, where



TEXT-FIGURE 2.

Showing the effect of the different types of management (as pre-treatments) on the number of tillers of each species per unit of area. In each case the highest number of tillers is taken as 100, and the value of each individual species on the other plots is calculated accordingly.

there was least interference by man and animals. In addition, cocksfoot has persisted much better under mowing conditions than under any form of grazing, also the harder the grazing on the grazed areas the smaller was the amount of cocksfoot in the sward. On the plots which were grazed every month, or every two months, the number of cocksfoot tillers was about one-fifth of that on the non-mown plot, whereas on the weekly grazed plots it was only a small fraction of that amount.

The figures for weeds, or miscellaneous herbage, excluding grasses and clover, are similar to those for cocksfoot and tall fescue, as they thrived better in the absence of the grazing animal. Unlike those grasses, however, they have done much better on the mown plots than on the unmown plot; this is very noticeable in the case of buttercup, which has practically disappeared from the unmown plot. Further, of the plots on which animals have grazed, the harder grazed areas have favoured the weeds, whereas there were fewer weeds on the plots grazed every two months than on any of the other plots, buttercup again being an exception (see Table III). Sweet vernal, unlike weeds, cocksfoot and tall fescue, has done equally well in the presence or absence of the grazing animal. On the other hand, it resembles weeds in that it thrived much better on the mown area than on the unmown area, and also it was nearly four times as plentiful on the plot grazed every week as it was on either the plot grazed every month or on that grazed every two months.

Yorkshire fog, unlike the above species, was present in greater amount on the grazed areas as compared to the ungrazed areas. It was almost twice as plentiful on the mown area as on the unmown, ungrazed area. On the grazed areas it gave results similar to cocksfoot, that is, it thrived much better on the under-grazed areas than it did on the hard grazed areas.

White clover and bent, like Yorkshire fog, were far more prominent on the grazed than on the ungrazed areas, and further on the non-grazed plots these species were present in much smaller quantities on the unmown areas than on the mown areas; in fact, white clover was only present in very small amount on the non-grazed, non-mown plot. Bent, however, showed a slight increase on the non-grazed, non-mown plot. In the grazed plots these two species were present in smaller amounts on the under-grazed plots, the hard grazed areas giving the highest figures.

When the botanical analysis was being made, all the moss was picked off by hand from each turf. It was then washed,

dried, and weighed. The relative amount of moss (by weight) is shown in Table I, and the figures indicate that the hard grazing was conducive to the growth of moss, while on the under-grazed and the ungrazed, unmown plots very little moss was present.

TABLE II.

Showing the relative number of tillers of certain species on the three plots subjected to hard grazing.

Species.	*Weekly grazing in*		
	Spring.	*Spring, summer and autumn.*	*Autumn.*
White clover	44.0	100.0	70.5
Bent	91.2	100.0	74.5
Sweet vernal	47.0	100.0	77.5
Tall fescue	82.0	60.0	100.0
Cocksfoot	69.2	7.7	100.0
Crested dogstail ..	24.2	45.0	100.0
Weeds (excluding seedlings)	28.0	49.2	100.0
Moss (by weight)	55.4	100.0	• 99.0

Table II shows the relative number of tillers of some of the species on the three plots which have been subjected to weekly grazing. It will be noted that not one of these species has developed its maximum tiller production on the plot which was hard grazed in spring. Three of the species, namely, white clover, bent, and sweet vernal, have produced their maximum number of tillers on the plots which were subjected to a weekly grazing throughout the grazing season. In addition, the number of tillers of white clover and sweet vernal have been reduced by about 25 per cent. on the plots grazed every week in autumn, and by over 50 per cent. on the plots grazed every week in spring. The number of tillers of bent was also reduced by 25 per cent. on the plots hard grazed in autumn, but by only about 8 per cent. on the plot hard grazed in spring.

Tall fescue, cocksfoot, crested dogstail, and weeds have more tillers on the plots grazed every week in autumn. Tall fescue and cocksfoot have been reduced by 18 per cent. and 30 per cent. respectively on the plots grazed weekly in spring, and by 40 per cent. and 98 per cent. on the plots grazed weekly throughout the summer. Crested dogstail and weeds have a smaller number of tillers on the plots grazed weekly in spring than on the plots grazed weekly throughout the grazing season; the

former being about 25 per cent. and the latter about 50 per cent. of the number on the plots grazed every week in autumn.

There was a similar amount of moss on the plot grazed every week in autumn and that grazed every week throughout the season, but there was only about one-third of that amount present on the plot grazed weekly in spring.

TABLE III.

Showing the actual number of (a) plants, and (b) seedlings of buttercup per sq. ft. on the different plots.

Plots.	*Fully established plants.*	*Seedlings.*
Grazed every		
1. Week in spring, summer and autumn	11.2	67.6
2. Week in spring, and every month in summer and autumn	6.0	24.8
3. Week in autumn, and every month in spring and summer	37.2	34.4
4. Month ...	7.6	19.2
5. Two months	12.0	2.4
Mown every		
6. Two months and removed ...	46.0	9.6
7. Two months and allowed to rot	24.0	2.0
8. Unmown and ungrazed	1.6	4.4

Buttercup was rather a prominent weed on these plots, and it was decided to count the young seedlings and the fully established plants separately; these results are shown in Table III. It is seen that both the number of plants and the number of seedlings were very low on the ungrazed, unmown plot. Further, on an average the number of established plants was greater on the mown areas than on the grazed areas, but the number of seedlings was far less. The plot grazed every two months contained a fair number of established plants, but very few seedlings, whereas on the plot grazed every month a considerably larger number of seedlings was found. Comparing the three plots which are grazed every week at different periods of the year, it is seen that on the plot which was grazed every week in spring, summer and autumn the number of seedlings is much greater than on the other two plots, while the plot grazed every week in autumn contains by far the largest number of established plants.

It would thus seem that buttercup cannot compete successfully with the tall uncut herbage of the unmown plot. On the

mown plots it has established itself very well, especially on the sub-plot where the mown herbage is taken off the plot, but it does not appear to be reseeding itself very freely. This seems to suggest that even with only a moderate amount of reseeding buttercup is able to establish itself exceptionally well, provided that it is not interfered with by the grazing animal and that the other herbage is not allowed to grow tall enough to smother it. On the plots grazed every two months the seedling establishment of buttercup is very low, but, on the other hand, interference by the grazing animal is very slight so that it has a moderate number of fully developed plants. The plots grazed every month contained considerably more seedlings than those grazed every other month, but fewer established plants. The figures for the three plots grazed every week in spring, summer or autumn are very interesting. The number of seedlings on the plots grazed every week throughout the grazing season is exceptionally high, whereas the number of established plants is rather low, suggesting that the grazing animal interferes with the plants before they are fully established. A similar state of affairs prevails on the plot grazed every week in spring, the interference at this period (spring) being more harmful than at other periods. On the plot which is grazed every week in autumn, the lenient grazing during spring and summer allows the previous year's seedlings to become well established in spring and summer, and, further, it does not interfere with flowering during the summer. Inspection of the plots in the early period of July showed the plot grazed every week in autumn to be full of buttercup flowers. By the middle of August, when hard grazing was due to begin, the flowers had withered and the seeds were ripening. The hard grazing following this served to press the seedlings into the ground ready for next season. The counts of seedlings in this plot were not exceptionally high; this was probably due either to the seeds not having germinated when the counts were made, or to the seedlings having been eaten by the sheep. However, even allowing for a smaller number of seedlings, the lenient grazing of the following spring and summer allows the seedlings present to reach maturity and to flower.

Yield of herbage.

All the herbage samples cut during 1938 were air-dried and then weighed. A summary of these weights is shown in Table IV.

TABLE IV.

Showing the yield of herbage (lb. per acre) (a) as hay and aftermath, and (b) as pasture on the plots after three and a half years pre-treatment. (Average of A and B).

	Plots grazed every		
	(a) *Week.*	(b) *Month.*	(c) *Two Months.*
Hay yields	2519	2884	3076
Pasture yields	2043	2312	2282
Average	2281	2598	2654
Difference between hay + aftermath and pasture yields	476	572	844

	Ungrazed plots.	
	(a) *Mown.*	(b) *Unmown.*
Hay yields	2046	3897
Pasture yields	1664	1909
Average	1855	2903
Difference between hay + aftermath and pasture yields	382	1988

From Table IV it is seen that the largest yield was obtained from the plot which had been neither grazed nor mown during the period of the experiment, whereas the poorest yield was obtained from the plot which had been mown four times a year during that period. The plots which had been grazed were intermediate, those which had been grazed every week giving the lowest, and that which had been grazed every two months giving the highest yields of the grazed plots.

The figures in Table IV also show that the yield of herbage as pasture cuts was in all cases lower than the yield as hay and aftermath cut. This difference varied from plot to plot, being least on the mown plots and increasing on the grazed plots, especially on the plots grazed every two months, reaching its highest point on the unmown, ungrazed plot where the yield of herbage as hay and aftermath is more than twice the yield from pasture cuts.

Yield of individual species.

After weighing the air-dried herbage, all samples were subjected to a botanical analysis, and from this it was possible to

calculate the yield of each species on every plot, both as hay and aftermath and also from the four pasture cuts. These results are shown in detail in Appendices II and III. A summary of these figures is given in Table V and Text-figure 8, showing the relative yield of the various species, the figures being the average for both the pasture cuts and the hay cuts. The aftermath cuts have not been analysed.

TABLE V.

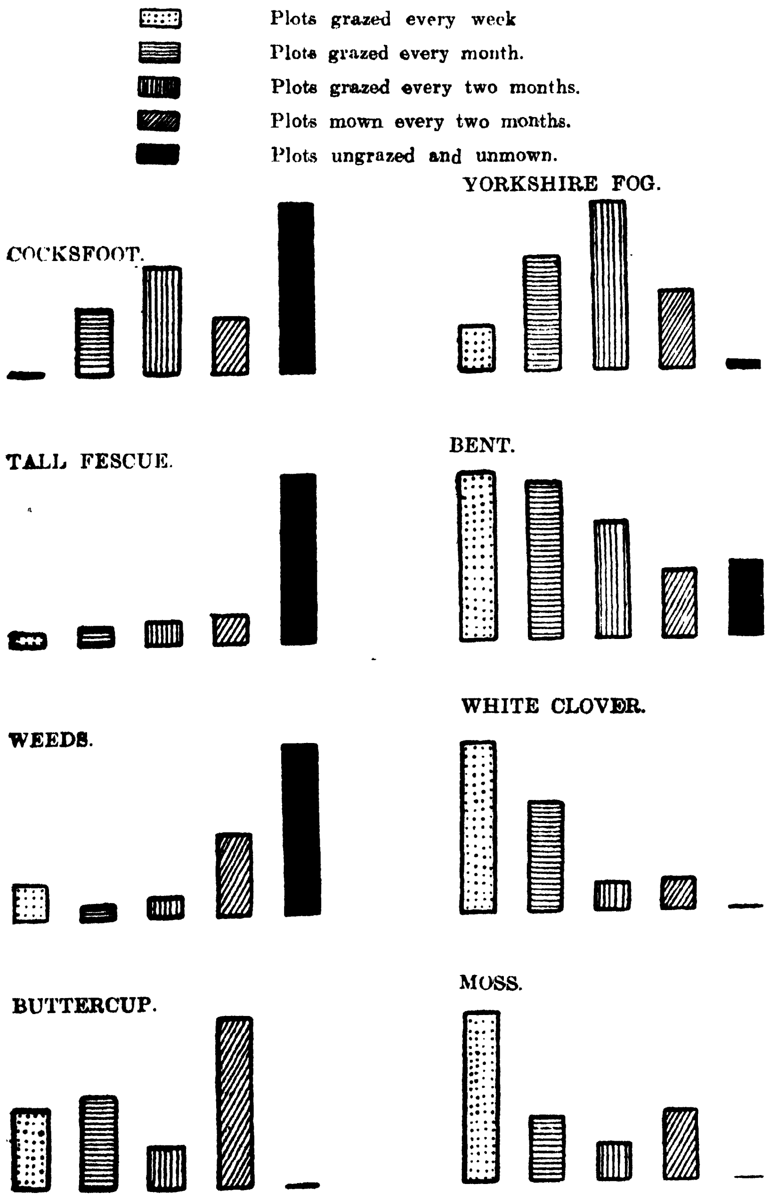
Showing the relative yield of the various species—average of the pasture and hay cuts for A and B series.

Species.	*Frequency of grazing.*		
	Week.	*Month.*	*Two Months.*
Cocksfoot	1.9	38.6	63.5
Tall fescue	7.6	10.5	13.8
Weeds (miscellaneous)	22.4	9.0	12.0
Buttercup	46.0 (75.5)*	54.0	24.2
Yorkshire fog	27.1	68.0	100.0
Bent	100.0	94.0	69.5
White clover	100.0	63.5	16.4
Moss	100.0	37.0	21.5

Species.	*No grazing.*	
	Mown.	*Unmown.*
Cocksfoot	33.4	100.0
Tall fescue	17.4	100.0
Weeds (miscellaneous)	48.5	100.0
Buttercup	100.0	Trace
Yorkshire fog	47.8	5.7
Bent	40.6	45.3
White clover	18.8	0.9
Moss	41.0	Trace

* The figure in brackets refers to yield of buttercup on the plot which was grazed every week in the autumn.

Table V and Text-figure 8 show that cocksfoot, tall fescue and the various weeds have given a much higher yield on the ungrazed, unmown plot than on any of the others. The yield of cocksfoot on the mown area was only one-third, and that of tall fescue only one-sixth of their respective yields on the untreated area. On the grazed areas cocksfoot gave a good yield on the plot grazed every two months—about two-thirds the yield of the untreated plot—but its yield on the plot grazed every month fell to about one-half and that on the plot grazed every week to less than 3 per cent. of its yield on the plot grazed every two



TEXT-FIGURE 3.

Showing the effect of the different types of management (as pre-treatments) on the yield of the various species. In each case the highest yield is placed at 100, and the value for each individual species on the other plots is calculated accordingly.

months. The yield of tall fescue gradually decreased from 18.8 on the plot grazed every two months to 10.5 on the plot grazed every month, and to 7.6 on the plot grazed every week; these figures are all relative, the yield of tall fescue on the untreated plot being placed at 100. These results for cocksfoot and tall fescue bear out the previous results (4, 5 and 6). Weeds gave only one-half as much herbage on the mown plot as on the untreated plot, and also their yield was greatly reduced on the grazed plots. Of these grazed plots the yield of weeds was nearly twice as much on the plots grazed every week as on the plots grazed every two months. The figures for buttercup are also of interest in that this plant has given its highest yield on the mown plots, where grazing was not carried out, whereas the unmown, ungrazed plot only showed traces of this species. Of the grazed plots, buttercup has given a far greater yield of herbage on the plots grazed every week in the autumn than on any other grazed plot, and the smallest yield on the plot grazed every two months.

Yorkshire fog gave its highest yield on the plot grazed every two months, its yield on the plot grazed every month being two-thirds, and on the plot grazed every week about one-quarter of that of the plot grazed every two months. Of the ungrazed plots, that which was mown every two months only yielded about 50 per cent. and the unmown plot about 5 per cent. of the yield given by the plot which was grazed every two months. Bent and white clover have both given the highest yield on the plot grazed every week. The decrease in the yield of bent on the plot grazed every month was only 6 per cent., whereas its yield has been reduced by over 80 per cent. on the plot grazed every two months. On the ungrazed areas the yield of bent has been reduced by 55 per cent. on the unmown area, and by 60 per cent. on the mown area. White clover shows more variation than bent and seems to be far more sensitive to the various types of management. On the plot grazed every month the yield of white clover has fallen to about two-thirds of its yield on the plot grazed every week, whereas it has dropped to about one-sixth of that value on the plot grazed every two months. The average yield of white clover on the plots mown every two months was similar to that on the plots grazed every two months, whereas its yield on the untreated plot was less than 1 per cent. of the yield on the plots which had been grazed every week. The amounts of moss in these herbage cuts are very similar to those obtained by hand-picking the moss from turfs (see Table I, p. 251).

In Table VI the figures shown for the area mown every two

months are the average of those for the two sub-plots. In order to compare the effect of cutting and removing the cut herbage, as against cutting and allowing the herbage to rot on the plot, the relative figures for these two sub-plots have been set out in Table VI. The amount of actual yield of herbage (in lb. per acre) is also given, from which it is seen that where the herbage was not removed after cutting there was an increase of 324 lb. in total herbage; this corresponds to an increase of about 16 per cent. On referring to the relative yield of the various species it is seen that this difference was not distributed uniformly amongst all the species. In fact, the yield of white clover, moss and buttercup was between three and four times as high on the plots where the herbage was removed after every mowing as on that on which it had been allowed to rot. The miscellaneous weeds and bent also showed 10 per cent. increase in the same direction. The other species, however, showed a lower yield on the area where the cut herbage was removed. This reduction in yield amounted to 20 per cent. in cocksfoot; 45 per cent. in tall fescue, and about 68 per cent. in Yorkshire fog, as compared to their respective yields on the plot on which the cut herbage had been allowed to rot.

TABLE VI.

Showing the relative yield of the various species on the mown areas.

Species.	*Areas mown every two months.*	
	Cut herbage removed.	*Cut herbage allowed to rot.*
White clover	100	25
Moss	100	29
Buttercup	100	38
Miscellaneous weeds	100	91
Bent	100	89
Cocksfoot	79	100
Tall fescue	54	100
Yorkshire fog	32	100
Actual yield of herbage (lb. per acre)	1698	2017
Relative yield of herbage	84	100

Discussion.

A study of the data collected from this experiment shows that each of the various pasture plants forming the sward was influenced in some way by the types of management adopted.

On this account the species can be grouped according to their reaction to the various types of management into :—

Group 1—those species which thrive best in the absence of the grazing animal.

Group 2—those species which thrive best under the influence of the grazing animal.

Group 2 may be sub-divided according to whether the plants are favoured by hard grazing or by very light grazing into :—

Group 2*a*—species favoured by light grazing.

Group 2*b*—species favoured by hard, close grazing.

Of the species which have been discussed in this paper, sweet vernal stands alone in that it does not fall into either Group 1 or Group 2 ; it is just as plentiful on the plots which are grazed every week as it is on the plots which are mown ; and further, the amounts present on the other grazed plots are similar to those on the untreated plot. One fact, however, stands out, namely, that sweet vernal did not thrive amongst tall herbage.

GROUP 1. *Species which thrive best in the absence of the grazing animal.*

Cocksfoot, tall fescue and the various weeds are the prominent members of this group. The first two species thrived exceptionally well on the plot which had been neither grazed nor mown for the last three and a half years. A comparison of Tables I and V shows that while the number of tillers of these two species was low on the mown plots, their yield was still lower compared to the yield on the untreated plot. This suggests that the individual plants of these two species were much stronger and better developed on the plot where there was least interference by man and the scythe. On the grazed areas both grasses make their best growth on the undergrazed areas and their poorest growth on the overgrazed areas ; this is much more noticeable in cocksfoot, which grass has practically disappeared from the hard grazed plot. Thus it seems that these two grasses thrive best when there is least interference by man and his grazing animals.

Miscellaneous weeds, or plants which are neither grasses nor clover, were more plentiful on the two mown plots, especially on the plot where the cut herbage has been removed. This indicates that when a pasture is being continually mown, and the herbage removed, it becomes more and more weedy. It is very

probable that this is largely a question of nutrition, the continuous removal of the herbage, with no animal droppings to replace it, depriving the soil of its plant food material. As a result, the grasses are not so robust, and thus are not so well able to keep out the weeds, which on the whole are better able to live under poorer conditions than are the grasses. However, it is quite probable that if this continuous cutting is followed by the application of manures, the grasses and clover will be better able to keep the weeds in check. Referring again to Tables I and V it is seen that though the number of weed plants was higher on the mown plots, the yield of the weeds is twice as great on the untreated plot. This shows that each weed plant on the unmown area gave nearly three times as high a yield of herbage as each weed plant on the mown area. Probably this was due partly to the fact that (*a*) the plants which were allowed to grow from year to year unhampered had stored more reserve food supply in their stems and roots, and were therefore more robust; and (*b*) different species of weeds predominated on the two plots. Yarrow, meadow vetchling, ox-eye daisy and bird's foot trefoil were present in much larger quantities on the unmown area whereas smaller types of weeds such as buttercup, dandelion, plantain, self-heal, speedwell and woodrush were more prevalent on the mown plots.

It was interesting to note that on the ungrazed, unmown area a few plants of bramble had come in, and whereas yarrow, ox-eye daisy and meadow vetchling were practically absent on the grazed areas, they were relatively plentiful on the ungrazed plots. On the other hand, chickweed and the smaller types of weeds were much more prevalent on the grazed plots.

Group 2. *Species which thrive best under the influence of the grazing animal.*

Of the species which were present in appreciable amount on this experiment, three, namely, Yorkshire fog, bent and white clover, have shown a distinct preference for the grazing animal. In other words, they have all thrived much better on the grazed plots than on the ungrazed plots. However, their behaviour is very different on the grazed plots.

Group 2*a*. *Species favoured by light grazing.*

Yorkshire fog was favoured by being lightly grazed, that is, on the plots grazed every two months. Compared with the plot grazed every week it had two and a half times as many tillers on the plot grazed every two months, whereas the latter gave four

times as high a yield of fog. On the ungrazed plots Yorkshire fog thrived much better on the mown areas, especially where the cut herbage was allowed to rot, whereas it did very badly on the untreated pasture where it gave less than 6 per cent. of its yield on the plot grazed every two months.

GROUP 2*b*. *Species favoured by hard, close grazing.*

Bent and white clover, on the other hand, have thrived best on the plots grazed every week, that is, continuous hard grazing has favoured these two species. On the plot grazed every two months the number of tillers of bent has been reduced to about one-half; whereas its yield has dropped to about two-thirds; and on the non-grazed plots the number of tillers of bent and the yield of this species have dropped to between one-half and one-third of their value on the plot grazed every week.

White clover, on the other hand, is much more sensitive than bent to changes in management. Compared with the plot grazed every week, the number of tillers of white clover has dropped to 40 per cent. and its yield to 16 per cent. on the plot grazed every two months, while both its yield and the number of tillers were below 1.0 per cent. on the ungrazed, unmown plot.

Thus of the species dealt with in this paper, commercial cocksfoot and wild white clover have reacted in entirely different directions. Management which increased cocksfoot decreased white clover, and *vice versa*, while management which favours bent usually favours clover.

Though the figures in Tables I and V showing the amount of moss on the different plots were obtained from different sources, they agree very closely. The figures for moss shown in Table I were obtained by picking-off all the moss from each turf during pasture analysis; this was then washed, dried and weighed. The figures shown in Table V, however, were obtained by separation of the moss included in the pasture cuts.

These figures show that the harder the degree of grazing the greater is the amount of moss, and that there is practically no moss present on the plots which have been allowed to grow unhampered.

Summary.

An account is given of an experiment set up to test the effect of different types of grazing management on the pasture produced.

The data collected have been presented to show (*a*) the effect of management on the botanical composition of the sward and (*b*) the effect of management on the yield, both as total

yield and the yield of the individual species after the pasture had been subjected to the various types of management over a range of three and a half years.

It has been shown that

(1) Cocksfoot and tall fescue thrive best where there is least interference by man, while they are extremely poor on the hard grazed plots.
(2) Weeds thrive best under mowing conditions.
(3) Yorkshire fog was better on the grazed than on the ungrazed area, but that it was favoured by light grazing.
(4) Bent and white clover thrive much better under grazing conditions than under mowing conditions, and within certain limits the harder the grazing the better do these two species thrive.
(5) Moss is also encouraged by very hard grazing.

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APPENDIX I.

Showing the average number of tillers of each species per sq. ft. on each of the plots in November, 1933. (Average of A and B series).

Species.	*Plot 1*	*Plot 2*	*Plot 3*	*Plot 4*	*Plot 5*	*Plot 6a*	*Plot 6b*	*Plot 7*
White clover	36.6	75.8	39.8	90.4	63.8	15.0	5.8	0.6
Bent	587.2	757.6	1034.8	1135.6	844.8	407.2	253.2	887.6
Yorkshire fog	211.6	140.4	186.4	87.6	72.8	72.8	116.4	49.6
Tall fescue	5.2	9.6	11.2	8.4	13.6	12.8	6.4	35.2
Cocksfoot	6.4	6.0	3.6	0.4	5.2	19.2	22.4	31.2
Sweet vernal	10.4	8.8	18.4	39.2	30.4	40.8	38.8	10.0
Fine-leaved fescue	48.4	58.0	56.0	30.0	43.6	29.6	37.2	10.4
Rough-stalked meadow grass	132.8	68.8	192.8	180.8	74.8	65.2	105.2	68.0
Crested dogstail	0.0	6.0	3.0	5.6	12.4	6.2	1.2	1.6
Other species (or weeds) ...	20.8	48.8	44.8	102.8	106.0	111.6	68.4	43.6
Total tillers	1059.4	1179.8	1590.8	1680.8	1267.4	780.4	655.0	637.8
Moss by weight in grams per sq. feet	0.64	5.22	2.90	8.18	8.10	7.42	2.42	0.18
Buttercup plants	12.0	7.6	6.0	11.2	37.2	46.0	24.0	1.6
Buttercup seedlings	2.4	19.2	24.8	67.6	34.4	9.6	2.0	4.4
Total buttercups	14.4	26.8	30.8	78.8	71.6	55.6	26.0	6.0
Weeds (excluding buttercups)	6.4	22.0	14.0	24.0	34.4	56.0	42.4	37.6

APPENDIX II.

Showing the actual yield of species as hay (lb. per acre). (Average of A and B series).

Species.	*Plot 1*	*Plot 2*	*Plot 3*	*Plot 4*	*Plot 5*	*Plot 6a*	*Plot 6b*	*Plot 7*
White clover	15	52	37½	91	42	35½	9½	2½
Bent	723	1154	1166	1167½	758	465	290	616
Yorkshire fog	821½	559	638	215½	191½	197	514	40
Cocksfoot	153½	25	26½	1½	8	58½	114	248½
Tall fescue	106	64	261	51½	29	59½	139½	1054
Rough-stalked meadow grass	23½	12	35½	82	10	12½	45	84
Grass weeds	141½	117	168½	184	249	198	182	401
Miscellaneous weeds	34	39½	76	110½	185½	280	270	767
Buttercup	13	22	11½	—	6	182½	39½	—
Moss	—	1	½	—	4	5½	—	—

APPENDIX III.

Actual yield of individual species as pasture cuts. (Average of A and B series).

Species.	*Plot 1*	*Plot 2*	*Plot 3*	*Plot 4*	*Plot 5*	*Plot 6a*	*Plot 6b*	*Plot 7*
White clover	20	83	59	122	57½	28½	7	Trace
Bent	837½	950½	994	1074½	825	479½	571	400
Yorkshire fog	637	428½	360	178½	194	136	531	48
Cocksfoot	189	183	51	8	18½	100½	86½	290½
Tall fescue	117	108½	189½	73	43	94	145	576½
Rough-stalked meadow grass	30	65	65	82½	28½	8½	18½	28
Grass weeds	261½	342	300½	231	295	198	189	220
Miscellaneous weeds	99	61	59	140½	120½	287	248½	349
Buttercup	27	67	69½	72	119	105	52	Trace
Moss	14½	23½	24½	65	36½	35½	12	7
Total yield	2232½	2312	2172	2047	1737½	1472½	1855½	1909

A SEEDS MIXTURE EXPERIMENT IN MID-CARDIGANSHIRE.

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In recent years considerable attention has been paid to the study of seeds mixtures for the laying down of land to grass. This interest was intensified as a result of the Ploughing Orders enforced during the war, which caused many good permanent pastures to be ploughed up. After the war, with the fall in corn prices, attempts were made to re-lay this land to grass. The reports of the Ministry of Agriculture show that the area of arable land in 1925 was nearly 1¾ million acres less than in 1918, which means that about ¼ million acres of arable land were laid down to permanent pasture every year during that period.

The unsuitability of ordinary seeds mixtures for the formation of permanent swards was clearly shown in these attempts at laying down land to grass. By the third year most of the sown species in the mixtures used had disappeared or thinned off considerably. After the second year, volunteer grasses, and in some cases a little volunteer clover, took the place of the sown grasses and clover. During this transition period the productivity of the pasture was very low, the sward being very thin with a high percentage of bare ground, and in a number of cases the final sward was composed of inferior species as compared with the sward

which was ploughed. Consequently, the output from such pastures was far below its potential capabilities, and the farmer lost financially.

One of the first problems investigated by the Welsh Plant Breeding Station was this question of seeds mixtures. Numerous experiments were conducted, using various species and different combinations of species, together with as many strains as possible of each grass and clover. The object was to find a seeds mixture which would form a good permanent sward in the shortest possible time.

In the early years of these experiments it was realised that certain species were far superior to others in the formation of pastures, especially if care were taken to obtain the proper strains of such species.

Usually a seeds mixture is expected to provide hay for one or two years, followed by a number of years of grazing. In these trials a modified form of the standard Cockle Park mixture was first employed, and subsequently the mixtures were greatly simplified. Consequently, in 1925, in conjunction with Mr. D. J. Morgan, Agricultural Organiser for Cardiganshire, the following seeds mixture was sown at twenty-five centres in mid-Cardiganshire in order to obtain further evidence :—

Italian rye grass	2 lb. per acre.
Wild perennial rye-grass*	14 lb. per acre.
Rough-stalked meadow grass	4 lb. per acre.
Montgomery red clover	6 lb. per acre.
Wild white clover	2 lb. per acre.

* *Ex* wild white clover.

The plots were 1/10th acre in size, and were usually placed in the middle of a field surrounded by the farmer's normal mixture. During the whole period the plot was left unfenced, so that it would receive the same treatment as the rest of the field, every farmer being given a free hand in the management of the field.

The farmer's mixture varied considerably from farm to farm, but on the whole it was constituted as follows :—

	Average Seeding. (*lb. per acre*).	*Variation.*
Italian rye-grass	4 lb.	2— 6 lb.
Perennial rye-grass	16 lb.	10—25 lb.
Cocksfoot	5 lb.	3— 6 lb.
Timothy	3 lb.	2— 5 lb.
Red clover	6 lb.	3— 8 lb.
Alsike	3 lb.	1— 5 lb.
	37 lb.	

Some farmers also included one or more of the following species :—

Meadow fescue	.... 1—2 lb.	
Tall fescue	.... 1 lb.	
Rough-stalked meadow grass	½—2 lb.	
Wild white clover	.... ¼—1 lb.	on 3 farms.

The total seeding varied from 25 to 45 lb. per acre, and in all cases the seed was of the usual commercial type, none of the more persistent strains—such as Montgomery red clover or wild perennial rye-grass—being used.

During April and May, 1928, that is, during the spring of the third harvest year, the writer made a botanical analysis of the experimental mixture and the farmer's mixture adjoining at twenty-one centres, the other four centres having already been ploughed. A brief report of this analysis appeared in the Cardiganshire Agricultural Organiser's report for 1928, and the present paper gives these results in greater detail. During the summer of 1932, the seventh harvest year, my colleague, Mr. T. Emlyn Jones, made a further survey of the seven centres which were still unploughed, and he has kindly allowed me to incorporate his results with the data of the third harvest year.

In addition to making a botanical analysis of the plots in 1928, the writer ascertained each farmer's opinion of the experimental plot. The only serious complaint against the experimental plot was that it was later than the farmer's mixture to start growth in the spring. According to most farmers this was more noticeable in the first and second harvest year when the fields were kept for hay. However, nearly every farmer pointed out that at harvesting time not only had the plot caught up the rest of the field but that in most cases it outyielded the farmer's mixture. In addition, it was far more leafy and less coarse than the farmer's mixture. In fact, one farmer's complaint was that his mowing machine could not cope with the dense, leafy hay of the experimental plot. All farmers agreed that the herbage on the experimental plot was more palatable than that on the rest of the field, and thus the pasture was kept much shorter. One farmer, however, complained bitterly about this, and said : " I will not sow any of that mixture on my farm again. It gives no growth, and my young calves prefer to starve on that plot rather than graze any of the other areas where there is plenty of food for them." Of course, he did not realise that if his calves were always grazing on that small area—1/10th acre—and there were five calves, he could not expect to find much growth there. This

closer grazing of the experimental plot was noticeable at all centres, and the dark green sward could be easily seen at distances of over a mile, standing out in contrast to the rest of the fields, on which some tall, burnt herbage occurred.

The consensus of opinion among the farmers was, however, that the "experimental plot mixture" was decidedly superior to the "farmer's mixture."

The results of the analyses for both years are shown in Table I. These figures indicate that within three years the sward of the farmer's fields consisted of 60 per cent. unsown species, and of only 40 per cent. of the species included in the seeds mixture. In 1932 (seventh harvest year) the replacement of the sown species by unsown species had proceeded much further (on the farmer's plot), the sown species contributing only 12.9 per cent., or about ⅛th of the total plants forming the pasture. In the case of the experimental plot the sown species took a far more prominent part in the formation of the sward. Even in the seventh harvest year the sward was composed of nearly 60 per cent. sown species, whilst in the third year the sown species accounted for over 75 per cent. of the tillers forming the sward. These figures show that the herbage of the experimental plot, even in the seventh year, was largely derived from the original seeds mixture sown; while as early as the third year the farmer's mixture was mostly composed of unsown grasses and clovers.

TABLE I.

Showing the percentage botanical composition of the farmer's mixture area and the experimental plot.

Species.	*Farmer's mixture area.*		*Experimental plot.*	
	1928.	*1932.*	*1928.*	*1932.*
Sown species	39.3	12.9	75.5	57.8
Unsown species	60.7	87.1	24.5	42.2
Perennial rye-grass	21.1	6.5	35.8	30.8
Rough-stalked meadow grass	3.9	12.0	20.3	15.8
Red clover	0.4	Nil.	3.1	0.1
White clover	7.5	4.5	16.3	11.1
Bare ground	26.5	14.6	12.0	13.9
Moss	11.3	5.2	6.3	3.7

A further comparison of the figures in Table I shows that :—

(*a*) Perennial rye-grass, though sown at a similar rate in both mixtures, was far less plentiful on the farmer's mixture area.

Even by the third year the amount of rye-grass in the sward from the farmer's mixture was only half that in the experimental plot, while by the seventh harvest year, the latter contained five times as much rye-grass. This difference in persistency was due to the strain of rye-grass included in the seeds mixtûre. All the farmers used the ordinary commercial strain in their seeds mixture, whereas that of the experimental mixture was obtained from good, *old* rye-grass—white clover swards.

(*b*) Rough-stalked meadow grass (which was included in only two farmer's mixtures) contributed but a fraction of the total tillers in the farmer's mixture area in 1928, while on the experimental plot, where it was sown at 4lb. per acre, it formed 20 per cent. of the total number of tillers. By 1932 the rough-stalked meadow grass had trebled on the farmer's mixture area, while on the experimental plot it had decreased slightly.

(*c*) Red clover was very low in both cases, but there was distinctly more on the experimental plot than on the farmer's mixture area. Probably this was due to the fact that the red clover sown in the plot was a Montgomery strain, while that sown by the farmers was a mixture of broad red clover and ordinary English late-flowering red clover in about equal proportions. This confirms previous results, namely, that Montgomery red clover is more persistent than other strains of that species.

(*d*) Wild white clover seed was included in only three of the farmer's mixtures. However, by the third harvest year it had encroached so much as to form about 7.5 per cent. of the total tillers of the sward in the farmer's mixture as compared to 16.8 per cent. on the experimental plot. In 1932 the amount of clover had slightly decreased on both pastures, but the experimental plot still had about two and a-half times as much white clover as the farmer's mixture.

(*e*) There was more than twice as much bare ground on the farmer's mixture area in 1928. In 1932, however, the amount of bare ground was practically the same in both cases and was similar in amount to that of the experimental plot in 1928. One striking point was the decrease in the amount of bare ground on the farmer's mixture area between 1928 and 1932. Correlated with this is the marked increase in the amount of rough-stalked meadow grass in the farmer's mixture area during this period. This suggests that at most centres the sward of the farmer's mixture area was changing rapidly when the analysis was carried out in 1928. The sown species had to a large extent

died out, while creeping grasses such as rough-stalked meadow grass and bent had not developed sufficiently vigorously to colonise this bare ground completely. Between 1928 and 1932, however, these grasses had spread and established themselves on the bare areas.

(*f*) There was far more moss on the farmer's mixture area than on the experimental plot both in 1928 and 1932.

When the botanical analysis was being made in May, 1928, it was noticed that flowers of buttercups and daisies were far more plentiful on the farmer's mixture area. As a result, counts of the number of plants and flowers of these two species were made (see Table II).

TABLE II.

Showing the number of plants and flowers of buttercups and daisies per sq. yd. on the two mixture areas.

	No. of plants.	*No. of flowers.*	*No. of flowers per 100 plants.*
Buttercups.			
Plots	31	5	16
Fields	68	43	64
Daisies.			
Plots	52	27	50
Fields	90	97	109

The number of plants of each of these weeds on the farmer's mixture was about twice that on the experimental plot. This would suggest that in the case of the experimental mixture the sown species retained the ground so well that encroachment by weeds was rendered difficult, while the sown species in the farmer's mixture died off to such an extent as to offer a large area of bare ground for weeds to colonise. In addition, however, it was noticed that the pasture on the experimental plot was grazed more closely than the rest of the field, and in many cases the farmers pointed out that the stock spent a larger proportion of their time on the plots in preference to the rest of the field. Thus it follows that these animals were bound to eat more of the leaves on the experimental plots and so retard the vegetative spreading of the plants. Furthermore, the figures relating to the number of flowers of these two weeds show that on the farmer's mixture area there were four times as many flowers of buttercups and more than twice as many flowers of daisies per 100 plants as on the experimental plot. This suggests that the

extra stocking, together with the closer grazing on the experimental plot, has resulted in a decrease in the number of flowers. This may be due to flowering being inhibited or to a high percentage of the flowers being eaten by the stock. In any case a decrease in the number of flowers means eventually a smaller crop of seeds, and, therefore, fewer seedlings.

Comparison of swards produced from the same seeds mixture.

This experiment also afforded an excellent opportunity of studying the sward produced from the same seeds mixture—the experimental plot—under different conditions. For this purpose the swards are grouped according to :—

(1) *Altitude.* When the swards are divided into two groups according to whether they are situated higher or lower than the 700 ft. contour (see Table III), it is shown that a smaller percentage of sown species was able to survive at the higher elevation. As a result there was more bare ground and moss at the higher elevation.

TABLE III.

Comparison of the swards produced from the experimental mixture at different altitudes (1928).

Altitude.	*Percentage of*			*Amount of moss.*
	Sown species.	*Weeds.*	*Bare ground.*	
Centres below 700 ft.	81	19	5.6	9.5
Centres above 700 ft.	74	26	7.5	14.8

(2) *Percentage sown species forming the sward.* A grouping of the swards according to the percentage sown species into three groups is shown in Table IV. In the best pastures were included all those plots which in 1928 consisted of over 90 per cent. of the herbage as sown species. In the poor pastures, the plots which consisted of less than 70 per cent. of sown species were placed, while in the medium pastures were included the plots between these extremes.

Table IV shows that :—

(*a*) The unsown grasses and the miscellaneous weeds increased at a similar rate from the best to the medium pastures, but the unsown grasses accounted for all the increase in unsown species between the medium and the poor pastures.

(*b*) Bare ground and moss increased markedly from the best to the medium and the poor plots. In fact the plots with the lowest percentage sown species had over two and a half times as

much bare ground, and three and a half times as much moss as the best plots, which contained the highest percentage of sown species.

TABLE IV.

Comparison of the percentage of sown species and the type of sward produced (1928).

	Percentage Sown Species.		
	Over 90 per cent; average 95 per cent.	*70-90 per cent.; average 81 per cent.*	*Under 70 per cent; average 57 per cent.*
Unsown grasses	3.0	10.5	35.0
Miscellaneous weeds ...	2.0	8.5	8.0
Bare ground	5.6	12.0	14.5
Moss	2.7	6.0	9.5

Percentage of white clover present.

In Table V the swards have been divided into two groups, according to the percentage of white clover present. The chief

TABLE V.

Comparison of the percentage of wild white clover and the type of sward produced.

	Amount of white clover.	
	9.0 per cent.—15.5 per cent.; average 13.3 per cent.	*17.5 per cent.—26 per cent.; average 21.0 per cent.*
Unsown grasses	18.2 } 27.1 per cent.	12.0 } 16.4 per cent.
Miscellaneous weeds	8.9 }	4.4 }
Bare ground	11.5	11.8
Moss	8.0	4.4

points noticed with the higher amount of white clover in the sward are :—

(*a*) The smaller amounts of weeds, notably weeds which are not grass. To some extent this would be expected, as it is known that nitrogenous manures favour grasses far more than they do the weeds of a pasture, and the probability is that the nitrification associated with white clover, in addition to favouring the better sown grasses, also helps the unsown grasses, but gives little or no benefit to the weeds. This encouragement of the grasses must have an adverse effect on weeds on account of the keener competition brought about by the increased growth of the grasses.

(*b*) That it had practically no effect on the amount of bare ground.

(*c*) That the amount of moss is considerably reduced. This is better shown in Table VI, which is based on the same data as Table V, plus data collected on the farmer's mixture area at each centre, and is arranged so as to give four groups for each of the two mixtures. The centres are grouped according to the percentage of wild white clover in the swards.

TABLE VI.

Showing the effect of the amount of white clover on the moss content of a sward. The figures in brackets refer to the number of centres in each group.

Amount of white clover in the sward.	*Amount of moss in sward.*		
	Farmer's mixture.	*Experimental mixture.*	*Average of both mixtures.*
0— 5.0 per cent.	13.2 (9)	— (0)	13.2 (9)
5—14.0 per cent.	12.0 (7)	8.7 (8)	10.2 (15)
14—20.0 per cent.	10.0 (8)	5.1 (7)	6.6 (10)
Over 20 per cent.	2.5 (1)	4.4 (5)	4.1 (6)

The figures in Table VI show that the higher the white clover content of the pasture the smaller is the amount of moss present. Swards containing less than 5 per cent. of white clover had more than three times as much moss as swards containing over 20 per cent. white clover. Considering that white clover is a source of nitrogen to the soil, this result is not wholly unexpected, since nitrogenous manures tend to decrease the moss in a pasture.

Propensity. In the first part of this paper it was shown that " unsown grasses " formed a high percentage of the pastures examined. This is nothing new, as it is well known that after a few years most pastures " revert " and finally consist of grasses and clovers which were not included in the seeds mixtures sown some years previously. A very important question arises from this, namely, to what extent should the natural herbage of a field affect its seeds mixture? One has often been told that on certain fields it is unnecessary to sow seed of wild white clover and rough-stalked meadow grass, as these species are " natural " or propense to them. An inspection of such fields in their third or fourth harvest year usually reveals the fact that though these " natural " and desirable plants are present in fair quantity their numbers are far below what one would consider satisfactory. Data collected in this survey throw further light on this question, as is shown by Tables VII and VIII.

TABLE VII.

Comparison of the percentage white clover on land where it had not been sown with its percentage contribution on the same land when sown.

	Farmer's Mixture Area.		*Experimental Plot.*	
	Wild white clover not sown.		*Wild white clover sown at 2 lb. per acre.*	
	Range.	*Average.*	*Range.*	*Average.*
		Per cent.		*Per cent.*
Group A	Under 5 per cent	... 3.3	9.0—22.0 per cent.	... 13.8
Group B	5.0—10.0 per cent.	6.7	15.0—21.0 per cent.	... 18.0
Group C	Over 10 per cent.	. 14.1	15.5—26.0 per cent.	.... 21.0

In Table VII all centres containing less than 5 per cent. of white clover in the pasture on the farmer's mixture area are placed in one group—Group A: those containing between 5.0 per cent. and 10.0 per cent. are placed in Group B, while those with more than 10.0 per cent. are placed in Group C. The average percentage of white clover was then found for each of these groups, both in the pastures derived from the farmer's mixture in which no wild white clover had been sown, and also in the experimental plot, where it had been sown at 2 lb. per acre.

Table VII shows that where wild white clover spread rapidly in a pasture where it had not been sown, that is, where wild white clover was propense to a pasture, it flourished still better when sown. On the other hand, fields in which white clover appeared in only small amount if not sown, were also relatively poor in white clover even where it had been sown. Thus the fact that white clover is propense to a certain field is an additional reason for including a pound or two of this species in the mixture, as it has already been shown that stock do much better on a pasture containing a high percentage of white clover than on a pasture from which white clover is absent or in which it occurs in but small amount.

TABLE VIII.

Comparison of the percentage of rough-stalked meadow grass on fields where it had not been sown with its percentage contribution on the same land when sown.

	Farmer's Mixture Area.		*Experimental Plot.*	
	Rough-stalked meadow grass not sown.		*Rough-stalked meadow grass sown at 4 lb. per acre.*	
	Range.	*Average.*	*Range.*	*Average.*
		Per cent.		*Per cent.*
Group **A**	Under 1.5 per cent.	.... 0.5	10.0—24.0 per cent	.... 18.8
Group **B**	2.0—4.0 per cent.	.... **2.5**	14.0—26.0 per cent.	.... **22.2**
Group **C**	Over 4 per cent.	.... **10.8**	22.0—28.0 per cent.	.... **27.8**

Rough-stalked meadow grass also has a tendency to establish itself in pastures without being sown. This tendency varies from field to field, as is shown in Table VIII, where the figures for this species have been arranged according to the same plan as that for white clover in Table VII. These figures, like those for white clover, show that where this grass had not encroached, or had encroached but slightly on a pasture when it had not been sown, it did relatively badly when sown; on the other hand, fields on which it established itself well when unsown, contained exceptionally large amounts of it on the experimental plot where it had been sown.

Summary.

A comparison is made between the swards produced from the ordinary mixtures of grass and clover seeds sown by the farmers and an experimental mixture recommended by the Welsh Plant Breeding Station.

From the cropping point of view, nearly all the farmers maintained that, although the experimental plot was later in starting growth in the spring, it yielded a larger and finer hay crop than their own mixtures.

It was also agreed that the herbage on the experimental plot was more palatable to stock, with the result that it was always closely grazed. No discoloured foggage was found on this plot, hence its striking green appearance on the middle of each field.

Botanically the experimental plot was a success in that it contained :—

(1) A much higher percentage of the sown species.

(2) Much more wild white clover.

(3) Fewer weeds.

(4) A smaller percentage of bare ground.

(5) Much less moss than the farmer's mixture area.

In the second part of the paper a study is made of the effect of different conditions on the botanical composition of the experimental plot.

It is shown that :

(1) The sown species disappeared more quickly from a sward at higher elevations than at lower elevations.

(2) As the percentage of sown species surviving decreased the amount of bare ground and moss increased rapidly.

(3) Where white clover was plentiful the moss content of the sward was low.

In the last section of the paper it is shown that in fields where white clover and rough-stalked meadow grass had a tendency to establish themselves well in the pasture when not sown, they did extremely well when sown, whereas on fields from which they were absent or on which they occurred but sparsely when not sown, they did relatively badly even when sown. Thus, even when a valuable grass or clover is " propense " to a field, the farmer should include it in his seeds mixture, and not be content to wait until it appears naturally.

THE INIMICAL EFFECTS OF PRESOAKING ON THE SEEDS OF OATS.

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It has been shown by several investigators (1, 2, 5) than an acceleration of germination follows upon presoaking the " seeds " of oats and that this in turn may favourably affect the later growth of the resulting plants (4). In all such work, the period of time during which soaking took place was comparatively short, and the seeds showed no injury from the subsequent drying to which they were exposed; it would seem probable that were the period of soaking to be prolonged, the seeds might pass into a condition in which they were no longer tolerant of being again dried. The experiments which are briefly described below were carried out in order to determine this matter.

Methods and Results.

Throughout the entire investigation a single sample of Ceirch-du-bach oats was employed. This had been raised at the Welsh Plant Breeding Station, and approximated closely to a " pure line." The presoaking was carried out in small (9 cm. diam.) Petri dishes; 20 c.c. of distilled water were measured into each dish, which contained 100 seeds. The amount of water was just sufficient to float the seeds, but was not deep enough to allow of their sinking below the surface after swelling of the grain had occurred.

The germination medium consisted in the first experiments of a thick pad of filter paper contained in a large (14.5 cm. diam.) Petri dish. The filter paper was first saturated with distilled water, and the excess water poured away; one hundred seeds were

placed in each dish. The dishes were placed in a cupboard out-of-doors and a daily record of the temperature was kept by means of a maximum-minimum thermometer. The results in each case are percentages of 300 seeds.

The seeds were put to soak at a temperature of 7°C. for varying periods with a difference of 12 hours between each, up to a maximum of 96 hours. Visible germination commenced in those seeds soaked for 72 hours and over. All the seeds were put out to dry on filter paper at the same time, and dried for a period of 24 hours at room temperature; they were set to germinate together with a control. Table I expresses the results. The roots of such seeds as had germinated during soaking had shrivelled in consequence of the subsequent desiccation; with these, "germination" in the table means the appearance of new roots or root-hairs, after setting out on the germination medium. In some cases no roots appeared, but water absorption took place directly, without the aid of root-hairs, and shoots appeared. These were not recorded as "germinated" for a stage was reached, after which no further growth took place, and the seedlings died back. Reference will be made to this point later.

TABLE I.

Germination of oats after increasing periods of soaking in water.

Germination per cent.	*Control.*	*Soaked.*				
		48 hours	*60 hours*	*72 hours*	*84 hours*	*96 hours*
After 2 days	Nil.	12.0	35.3	Nil.	Nil.	Nil.
After 3 days	Nil.	56.6	59.3	12.3	1.3	2.0
After 4 days ..	57.0	80.2	79.3	37.6	14.8	9.3
After 5 days	97.0	91.2	95.6	48.6	18.9	13.6
After 6 days ...				52.0	28.5	18.6
After 7 days ...				55.0		
After 10 days				59.3	38.4	29.0

Temperature range 3.05°C.—11.5°C. Average 6.6°C.

An acceleration is shewn by both the samples which have been soaked for 48 and 60 hours respectively. The soaking and redrying in the other three samples (soaked for 72, 84 and 96 hours respectively) have quite evidently been injurious. Germination is slower, and also the total germination is much less than that shewn by the control.

Soaking for a period slightly less than that required for visible germination (60 hours in the above table, but this period is dependent on temperature) had no adverse effect, when the seeds

were germinated on filter pads, but it is interesting to determine whether the same is true of seeds sown in the field.

Four samples of seed were treated as follows :—

A. Control, untreated.

B. Soaked for a period less than that required for visible germination (24 hours at 15°C.).

C. Soaked for a period very slightly less than that required for visible germination to take place under the prevailing conditions (42 hours at 15°C.).

D. Soaked for a period in which germination occurred.

The last three samples were put out to dry at the same time, and were dried for 24 hours. They were sown in drills, 10 gm. per drill, in a uniform piece of ground; the drills were 8 feet long, 1½ inches deep and 6 inches apart, and each drill was replicated eight times. The germination results are expressed as percentages in Table II.

TABLE II.

Germination in the field of oats soaked for increasing periods.

Germination per cent.	*A*	*B*	*C*	*D*
After 5 days	1.31 ± 0.03	37.85 ± 0.92	17.67 ± 0.44	5.48 ± 0.14
After 6 days	41.06 ± 1.00	83.98 ± 2.05	59.54 ± 1.45	29.86 ± 0.73
After 7 days	74.78 ± 1.87	94.44 ± 2.30	77.19 ± 1.90	50.38 ± 1.23
After 8 days	88.98 ± 2.17	95.42 ± 2.33	87.18 ± 2.12	59.42 ± 1.48
After 10 days	96.43 ± 2.35	99.92 ± 2.22	93.28 ± 2.27	67.81 ± 1.65

Sample C, the seeds of which were soaked for a period slightly less than that required for visible germination, shews less acceleration than sample B. Some injury, therefore, results if presoaking is continued to this point, but is not apparent if the seeds are germinated on filter paper. Comparing Tables I and II, the maximum figures for the D sample in Table II are much higher than the corresponding figures in the last three samples in Table I. It has been mentioned, in connection with Table I, that many seeds produced shoots but no roots. These grew to a considerable height, and the first leaf in most cases emerged. These would be counted as germinated in the field though, as on filter paper, they subsequently died back. Presoaking, therefore, has a beneficial effect on germination only when the treatment is carried out for a short time (24 hours at 15°C.) compared with that required for germination.

When all the seedlings had germinated, they were singled until those left were approximately 1 in. apart. This was necessary in order to make each row uniform because, as the figures indicate, some were denser than others. A series of weekly measurements on the height of the seedlings was commenced to determine whether the pre-soaking of the seeds affects subsequent growth of the plants. The first measurement was taken three weeks after the date of sowing. The results are presented in Table III, the figures giving the average height in millimetres of 200 plants, and, in the second column, the increase in height over the previous readings is shown.

From Table II it is seen that germination of the fourth sample, D, was much slower than that of the control, and Table III shows that the average height resulting from the former is less. No significant difference is apparent in the average height of the other three samples, and also the average height of all four samples increases at the same rate (at least until seven weeks from the date of sowing). This would seem to lend support to the conclusion of Knott (8), who found that soaking seed of beet, cabbage, and tomato had no definite influence on later growth and yield, if the plants from soaked and from dry seed appeared above ground at the same time. The "efficiency index" of a plant being highest in the early stages, favourable conditions at this time will have a marked effect on growth. The increase in vigour of plants obtained by many workers, as a result of presoaking the seed, would seem possibly to be due to the fact that plants from presoaked seed, appearing above ground earlier, have experienced more favourable climatic conditions during the initial stages of growth.

Discussion.

The results described above have some significance to agricultural practice with reference to the weather conditions which may prevail at the time of sowing and of harvesting grain. After cutting, the grain is left standing in the stook for upwards of a fortnight, and if wet weather occurs at this time, it is a matter of common observation that germination of the seed often follows. When, however, this wet weather is of short duration and is followed by warm, dry days, the seeds will be comparable to those soaked and dried in the foregoing experiments; the same is also true of lodged grain which becomes saturated with water, and is subsequently harvested. In such cases even if the emergence of the radicle has not taken place, the initial stages of the

TABLE III.

Growth of seedlings from presoaked and control seeds,

	1st measurement three weeks after sowing.		*2nd measurement four weeks after sowing.*		*3rd measurement five weeks after sowing.*		*4th measurement six weeks after sowing.*		*5th measurement seven weeks after sowing.*	
	Total height. mm.	*Increase.*	*Total height. mm.*	*Increase.*	*Total height. mm.*	*Increase.*	*Total height. mm.*	*Increase.*	*Total height. mm.*	*Increase.*
A.	175.83	0	209.54	33.71	231.7	25.2	261.32	27.62	292.62	31.3
B.	174.00	0	205.55	31.55	229.3	23.75	257.00	28.70	287.90	30.9
C.	173.67	0	201.71	28.04	227.9	26.19	254.80	26.90	284.30	29.5
D.	161.825	0	185.08	23.255	209.4	24.32	233.70	24.30	272.90	29.2

germination will have been passed through, so that, in the light of the results in Tables I and II, the effect will depend on the advancement of the stage reached when drying begins.

The results also give some indication of the effect on the seed of moist conditions at the time of sowing being followed soon afterwards by drought—an alternation which sometimes causes " malting " of the seeds. The effect of drying on the soaked grains is seen from Table II to depend on the stage to which germination has proceeded by the end of the period of soaking. Up to a stage just preceding the emergence of the radicle the seed suffers no adverse effect from drying, but at this and subsequent stages the drying has very definitely a deleterious action. When, then, sowing is followed by a period of drought, the injury produced will depend on the duration of the initial moist conditions. It ought, however, to be noted that the situation suggested here is only likely to obtain with extreme rarity in the case of oats, since they are almost invariably sown at a time of the year when any rapid alteration in soil moisture does not occur.

Summary.

1. Soaking the seeds for periods up to the time in which germination occurred, followed by re-drying, was found to increase the energy of germination, when the seeds were germinated on wet filter paper, but, when the seeds were sown in the field, soaking for a period slightly less than that in which germination occurred was found to be injurious.

2. Soaking for periods in which visible germination occurred, followed by re-drying, was found to be injurious, both when the seeds were germinated on filter paper and when sown in the field.

3. No increase in vigour of seedlings was obtained as a result of presoaking, but the initial advantage of earlier germination is maintained during later growth.

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THE EFFECT OF "CERESAN" ON THE GERMINATION OF GRASS-SEEDS.

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The trade-preparation "Ceresan" is one of the many compounds which have been claimed to cause a stimulation of germination. By the latter expression has usually been meant an acceleration of the initial development of the seedling, and such an effect has been shown by Sampson and Davies (2)[1] in the case of wheat to be due solely to the fungicidal action of the compounds employed and not to any true physiological stimulation of the seed. Experiments performed by the present writer (1) into the possibility of stimulation by several chemical compounds also gave entirely negative results. The markedly beneficial effects, however, which have followed the treatment of cereals with "Ceresan" in practical agriculture make it desirable to determine exactly the action of this substance on grass-seeds, since the germination of the latter in the field is often unsatisfactory.

The seeds used in the present experiment were a sample of indigenous cocksfoot (*Dactylis glomerata*) grown in Britain, and commercial samples of tall fescue (*Festuca elatior*) and red fescue (*F. rubra*); the samples had been stored 5-12 months from the time of harvesting. These three species of grass were chosen because of their being characterised by slow (and sometimes poor) germination, since this increases the likelihood of any differential behaviour by the treated seeds being revealed.

The Ceresan powder was added to the seeds in the proportion of one part Ceresan to one hundred, two hundred, six hundred and one thousand parts by weight of seed respectively, and intimately mixed with the latter by shaking vigorously in a closed phial for five minutes. The seeds so treated, together

[1] Much of this work was directly concerned with the operation of the compound "Tillantin R"—a preparation synonymous with "Ceresan."

with controls were set to germinate on moist filter-paper discs and in sterilised soil. The details of these methods have been given in a previous publication (1), but it should be noticed here that in the former case the visible germination of the seeds is alone involved, whereas the results obtained from the soil experiments may be influenced by any effect which may operate on the initial seedling growth. Any action which the Ceresan may have on the later growth of the seedlings has not been considered in the present work.

The figures in all the tables are in each case averages obtained from three hundred seeds.

TABLE. I.

Percentage germination in sterilised soil of seeds treated with Ceresan (temperature 10°—22°C. Average 15°C.).

	After 7 days.	*After 10 days.*	*After 14 days.*	*After 18 days.*	*After 32 days.*
D. glomerata Untreated	24.3	35.6	52.6	70.6	79.0
„ + 1/100 Ceresan	9.6	23.6	45.3	60.6	81.6
„ + 1/200 Ceresan	13.6	25.3	41.3	51.3	70.3
„ + 1/600 Ceresan	13.6	27.3	45.0	59.0	70.0
„ + 1/1000 Ceresan	19.6	34.3	56.6	71.3	81.3
F. rubra Untreated		7.0	20.0	21.6	28.0
„ + 1/100 Ceresan		1.0	6.3	9.6	16.8
„ + 1/200 Ceresan		4.0	18.3	20.6	23.6
„ + 1/600 Ceresan		6.3	16.6	18.0	20.6
„ + 1/1000 Ceresan		6.0	15.0	18.3	18.6
F. elatior Untreated	46.8	65.3	70.8		72.8
„ + 1/100 Ceresan	21.0	45.6	59.0		73.6
„ + 1/200 Ceresan	32.0	55.3	68.0		68.0
„ + 1/600 Ceresan	46.3	63.6	70.6		75.0
„ + 1/1000 Ceresan	38.6	62.0	69.8		72.0

Consideration of Tables I—III shows that neither from the seeds in soil nor from those on filter paper is there any evidence of any acceleration of germination by the Ceresan; on the contrary, a definite retardation has resulted from its application at the higher concentrations. The variation in the latter (*viz.*, from one in a hundred to one in a thousand) is extreme, yet the inimical action of the Ceresan in delaying germination is not large over the entire range, and moreover, the final germination of the treated seeds approaches, and in some cases slightly exceeds, that of the controls. It is, therefore, clear that the Ceresan is comparatively innocuous to the seeds themselves, and that an exact

precision in the application of the compound is not required. These properties are rare in fungicidal substances, but where present, both greatly facilitate the use of the latter in farming practice; the fact that Ceresan possesses them in an eminent degree suggests that its use by practical men should be attended with little risk of serious injury to the seeds treated.

TABLE II.

Percentage germination on filter-paper discs of seeds treated with Ceresan. (Temp. 3°—12°C. Average 8°C.).

	After 13 days.	*After 17 days.*	*After 27 days.*	*After 33 days.*
D. glomerata Untreated ...	36.0	42.6	71.6	77.0
,, + 1/100 Ceresan ...	25.0	37.6	70.0	77.0
,, + 1/200 Ceresan ...	19.0	30.6	64.6	72.3
,, + 1/600 Ceresan	24.3	32.6	66.0	70.3
F. Rubra. Untreated ...	7.6	12.0	41.6	48.3
,, + 1/100 Ceresan ...	3.6	7.3	42.3	52.6
,, + 1/200 Ceresan ..	8.0	13.0	54.0	59.6
,, + 1/600 Ceresan ...	5.0	14.0	49.3	56.0
F. elatior. Untreated	51.6	58.0	70.0	71.3
,, + 1/100 Ceresan	28.0	34.3	72.0	71.0
,, + 1/200 Ceresan	51.0	57.6	71.6	74.0
,, + 1/600 Ceresan ...	52.3	59.0	70.0	71.6

TABLE III.

Percentage germination on filter-paper discs of seeds treated with Ceresan. (Temp. about 17°C.).

	After 7 days.	*After 10 days.*	*After 22 days.*	*After 28 days.*
D. glomerata. Untreated	3.0	6.6	64.6	75.6
,, + 1/600 Ceresan	2.3	5.0	62.0	79.0
,, + 1/1000 Ceresan	1.3	2.3	62.0	69.6
F. rubra. Untreated		14.6	26.6	27.3
,, + 1/600 Ceresan		13.0	28.6	24.6
,, + 1/1000 Ceresan		14.3	26.3	26.6
F. elatior. Untreated	64.3	72.6	76.6	76.6
,, + 1/600 Ceresan	56.3	69.0	74.0	74.6
,, + 1/1000 Ceresan	60.0	73.6	77.6	78.6

Although it is necessary to emphasise that no physiological stimulation can be attributed to the Ceresan, the peculiar way (particularly with *D. glomerata*) in which increments to the number of germinated seeds continue to occur over a long period of time with the treated samples (so that the final germination of the latter may slightly exceed that of the controls) shows that some benefit may accrue to the slower-germinating seeds from the application of the compound, and suggests also that such benefit is the result of a protection of the seeds against fungal attack. Evidence that this supposition is correct is provided by the behaviour of seeds which have remained dormant in the soil for a considerable time owing to conditions unfavourable to germination obtaining.

TABLE IV.

Percentage germination (at the higher temperature) in sterilised soil of seeds treated with Ceresan, left for three weeks at 4.5°C., and afterwards removed to a higher temperature.

	After 5 days.	*After 7 days.*	*After 11 days.*	*After 18 days.*
F. rubra. Untreated	11.3	40.0	52.3	54.3
,, + 1/1000 Ceresan	12.3	41.0	51.6	56.6
F. elatior. Untreated	15.0	30.0	34.3	37.0
,, + 1/1000 Ceresan	20.3	15.3	52.6	53.3

The results given in Table IV were obtained from seeds the germination of which had been inhibited over a period of three weeks by the maintenance of a low temperature (about 4.5°C.). At the end of this time, the dishes containing the seeds were transferred for seven hours of each day from that temperature to one of 22°C.; the figures in the table represent the germination which immediately followed this alteration. It will be seen that the beneficial effect of the Ceresan is immediately operative from the commencement of germination—a result strongly suggestive of prevention by the Ceresan of fungal invasion of the seeds during the inhibitory period. The seeds used in this experiment had been harvested more recently than those described above, and a control experiment in which the alternation of a temperature of 4.5°C. with one of 22°C. was maintained from the beginning, was carried out using these younger seeds. The results are not, however, tabulated, since they resemble those summarised in Table I.

A similar increase of initial germination due to Ceresan treatment (*cf.* Table V) has been obtained in the case of cocksfoot seeds kept at a favourable temperature in soil rendered unsuited to germination by excessive moisture. There can, therefore, be no doubt that the slight apparent acceleration of germination, which in these later experiments (Tables IV and V) has followed treatment with Ceresan is due to the fungicidal action of that preparation.

TABLE V.

Percentage germination of seeds treated with Ceresan in soil excessively wet. (Temp. 22°C. for 7 hours and 4.5°C. for 17 hours of each day).

	After 10 days.	*After 14 days.*	*After 28 days.*	*After 46 days.*
D. glomerata. Untreated	3.3	11.3	18.3	27.6
,, + 1/200 Ceresan	5.3	15.0	27.0	34.6
,, + 1/1000 Ceresan	4.6	13.3	21.0	33.3

It seems possible from these results that the application of Ceresan to grass-seeds previous to their being sown in the field might often be markedly beneficial in practical farming, the value of such an application increasing in proportion as the conditions under which the seeds were sown were inimical to germination. A suitable proportion to use would seem to be one part of Ceresan to six hundred or one thousand parts by weight of seed.

Any definite recommendation of such employment must, however, await the result of experimentation on a large scale under field conditions.

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"SUCTION-FORCE" MEASUREMENTS ON THE SEEDS OF SOME VARIETIES OF OATS.

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Attention was first directed to the possibility of a correlation between the osmotic properties of seedlings and the subsequent growth of the resulting plants by Eibl in 1926 (4; 5) who found a direct correlation between high suction-force and early maturity in wheat and rye. In later years many investigations into this subject have been made, but since a fairly comprehensive review of the literature has already been given in this *Journal* by Chippindale (2), it will here be sufficient to refer only to the controversy which has arisen regarding the possibility of the "suction-force maximum" of seeds being dependent on the environment under which they have developed. Buchinger (1) and other workers believe that the suction-force of a strain of seeds is a constant character specific to that strain and is not affected by normal environmental conditions. Meyer (7; 8) on the contrary has obtained evidence that the latter modify considerably the germination behaviour of the seed and hence determine in part the suction-force of any sample.

There have been developed at the Welsh Plant Breeding Station a number of varieties of oats suitable for local conditions, and which differ markedly in growth behaviour from the usual commercial varieties. Moreover, there are certain of the latter which are sufficiently closely bred to approximate to "pure lines." There were, therefore, available to the writer a considerable number of varieties representing closely bred strains, and differing very markedly in vegetative behaviour. Hence it was considered that determination of the suction-force of several such strains should furnish evidence as to which of the opposing views mentioned above is correct.

Material and Methods.

A number of preliminary experiments were carried out on the varieties listed in Table I, which also gives their characteristics and the sources of the seed.

These experiments made evident the fact that the addition of formalin and sodium bicarbonate in the concentrations which have been recommended by Pammer (9), or even in half these concentrations, is markedly inimical to the germination of oats. The addition of 0.1 per cent sodium bicarbonate alone depressed

TABLE. I.

Variety.	*Characters of growth.**	*Source of seed.*
Orion	Early ripening; low tillering	1
Radnorshire Sprig	Early ripening; medium tillering ..	3
Superb	Early ripening; low tillering . .	2
Supreme	Early ripening; low tillering .	2
Abundance	Medium ripening; medium low tillering	2
Golden Rain II . .	Medium ripening; medium low tillering	1
Victory	Medium ripening; medium low tillering	1
Record	Medium ripening; medium low tillering	2
Scotch Potato . .	Late ripening; medium high tillering	2
Black Tartarian	Late ripening; low tillering . .	2
Grey Winter .	Late ripening; high tillering . . .	3
Ceirch-du-bach	Late ripening; high tillering . . .	3

1. Trade samples obtained from Messrs. Temperley and Co., 2, St. Nicholas Buildings, Newcastle-on-Tyne.

2. Trade samples obtained from Messrs. Gartons, Ltd., Seed Merchants, Warrington.

3. Samples grown at the Welsh Plant Breeding Station.

* The writer is indebted to Mr. E. T. Jones, M.Sc., for the descriptions of the varieties given in this table.

germination slightly, but the presence of 0.05 per cent sodium bicarbonate prevented the development of excess acidity and did not influence germination adversely.

In both the preliminary and the present work the seeds were germinated on rafts of the type described by Chippindale (8) which were floated on the surface of the test solutions contained in tins (such as those in which Rowntree's " Clear Gums " are sold), the inside of each tin being coated with a thin layer of paraffin wax.

Five hundred cc. of sugar solution were measured into each tin; the concentrations varied from 0.1 N upwards, increasing by 0.05 N, until the suction-force maximum was reached; all the solutions contained 0.05 per cent sodium bicarbonate. Ten seeds were the most convenient number to place in each groove of the raft, so that by using thirty seeds of each variety four varieties could be placed on one raft. Three tins of each concentration of sugar solution were used, so that the total number of seeds, on which the results were calculated, was ninety. There were also three tins with distilled water containing 0.05 per cent sodium bicarbonate. In all cases the seeds were incubated at 22°C.

Each experiment was run for ten days, the solutions being changed every other day. There was no check on fungal growth, but in changing the solutions, the rafts with grains on were lifted out, and as much fungus as possible removed with forceps. The trays were washed out, and any fungus in the tray was removed with a soft cloth; also before and after each experiment the tins and rafts were sterilized with 90 per cent. alcohol. The pH values of all solutions at the commencement and end of the experiment were determined colorimetrically, by comparison with the chart drawn up by Clarke (11); in the beginning the reaction of all the solutions was pH 8.4, but the subsequent changes varied with the different solutions, the most extreme degree of acidity to be reached being pH 6.0.

Germination counts were made on the second, fourth, sixth, etc., day of the experiment, i.e. at the same time as the solutions were changed, the germinated seed being removed in each case. Germination tests, according to the usual convention of a seed testing station, were carried out at the same time as the experiment was proceeding.

Results.

The results obtained in the preliminary work are summarized in Table II.

TABLE II.

Germinational behaviour of oat varieties (grown in different environments).

Variety.	*Suction-force Maximum. (Normality of sugar solution).*	*Germination.* %	*Germination energy.* %
Orion	.50 N	100	99.0
Golden Rain II ...	.45 N	99	99.0
Record	.45 N	93	91.3
Superb	.45 N	100	99.6
Abundance . . .	.45 N	98	94.6
Supreme	.40 N	86	85.3
Victory	.25 N	80	76.6
Black Tartarian	.35 N	94	91.6
Scotch Potato	.35 N	92	83.0
Grey Winter	.35 N	98	94.6
Ceirch-du-bach	.25 N	79	59.0
Radnorshire Sprig	—	59	39.0

No indication is given by the above figures of any agreement between value of the suction-force maximum, and those either

of germination or of germination energy obtained from ordinary germination tests.

It is of interest to note that, with the sample of Radnorshire Sprig, it was not found possible to determine the suction-force maximum, since the germination was below 50 per cent. of that obtained in water even in 0.1N solution of sucrose. The germination figures for this variety shew conclusively that the sample was of very inferior quality. The low suction-force maximum of the variety Victory is likewise possibly associated with the germination figures, which were unusually low for this variety. The work on these two varieties, therefore, lends support to the conclusion of Meyer (7 ;8) that samples of seed of low germination energy are entirely unsuited for tests in sugar solutions.

The figures for the remaining ten varieties form two distinct groups. The first six, viz., Orion, Golden Rain II, Record, Superb, Abundance and Supreme, were all found to have relatively high suction-force maxima. Within this group it is perhaps significant that the variety Orion, which is the earliest of all in time of ripening, was found to have very decidedly the highest suction-force maximum. There is, however, within this group of six varieties no further differentiation shewn which can be co-ordinated with growth behaviour. There is no evidence whatsoever of any relationship between the suction-force of the seeds and the tillering capacity of the varieties.

There remains, however, a second group of varieties, which was found to have low suction-force maxima, and it is extremely interesting to find that these are also characterized by a longer period of development, and a later date of ripening than the varieties previously mentioned. To this extent, therefore, the results of the preliminary work do shew an association between high-suction force and early maturity.

The results described above were obtained by employing small numbers of seed, also the seed was obtained from a variety of sources and was of somewhat variable quality. It was obviously desirable that they should be confirmed (or otherwise) by experiments employing a larger number of seeds, and seeds which had been grown and harvested under identical conditions.

The present work, therefore, has been carried out on seeds of the above mentioned varieties (Thousand Dollar being substituted for Grey Winter), which were grown and harvested at the Welsh Plant Breeding Station. Only sufficient seed was sown to provide the quantity necessary for the experiments, so that all

varieties were grown in a small space aand as nearly as possible under the same conditions.

The behaviour of the varieties in the different concentrations is given in Table 3 and the results of the germination tests are also recorded. The approximate value of the concentration equivalent to the suction-force maximum of each variety was first obtained by germinating the seeds in sugar solutions which increased in strength by 0.1N. A more exact examination was then made with solutions increasing in strength by 0.05N.

TABLE III.

Germinational behaviour of oat varieties (grown together in the same environment).

Variety.	*Suction-force maximum. (Normality of sugar solution).*	*Germination.* %	*Germination energy.* %
Orion	.65 N	98.0	97.3
Golden Rain II	.65 N	97.0	95.6
Abundance	.65 N	96.6	96.8
Record	.60 N	97.3	96.3
Ceirch-du-bach	.55 N	99.0	96.0
Superb	.50 N	96.0	95.3
Supreme	.50 N	97.0	93.0
Victory	.50 N	95.0	92.6
Radnorshire Sprig	.50 N	90.0	81.3
Scotch Potato	.50 N	97.0	97.0
Black Tartarian	.50 N	90.0	88.0
Thousand Dollar	.50 N	94.6	94.6

The values obtained for the suction-force of the different varieties again shew no agreement with those of germination or of germination energy obtained from ordinary germination tests, so that it is clear that the latter are incapable of supplying any information, which may be obtained from germination in sugar solution.

Comparing Tables II and III it is clear that the suction-force maximum is with each variety higher than that previously found. It is evident, therefore, that the suction-force is not a constant character, but is dependent in part on the environment under which the seeds have developed. This is in accordance with the view of Meyer (7), (8) (in contrast to that of Buchinger (1)) given above.

The suction-force values in Table III do not confirm the arrangement of the varieties, according to this criterion, which was obtained from the earlier experiments (cf. Table II). Orion,

Golden Rain II, Abundance, Record, Black Tartarian and Scotch Potato do indeed occupy the same positions relative to each other, but there is no differentiation shewn between Superb and the varieties Black Tartarian and Scotch Potato, and the late oat Ceirch-du-bach has the fifth highest suction-force, whereas in Table II it has the lowest of all.

From these later figures no evidence can be obtained of any correlation between the growth-behaviour and the suction-force value of the variety. Thus Thousand Dollar, which in habit is almost identical with Abundance, exhibits a much lower suction-force than the latter, and the early variety Radnorshire Sprig also occupies an anomalous position. Again, Ceirch-du-bach which is the latest of all the present varieties shows a fairly high suction-force. It is further noteworthy that the values of the latter for this variety in Tables II and III shew a difference in excess of that between the extreme values for all varieties in Table III. Hence the possibility of using suction-force as a diagnostic of strain or variety would seem remote.

The figures in Tables II and III further indicate, with most varieties, that : (i) there is very little difference in germination energy between the seed of the two years, and, in contrast to what is the case with the suction-forces, the differences are not always in favour of the second year; (ii) there is very little difference between the germination energy and the total germination; and (iii) the variation in germination energy shewn by the different varieties in the same year is slight. It is clear, therefore, that germination in sugar solutions furnishes a more rigorous test of seed vigour than does the germination energy obtained in the orthodox way.

It is noteworthy that the seeds used in the second series of experiments were ripened under exceptionally favourable conditions. The resulting increase in vigour, which is demonstrated by the uniformly higher suction-forces of all the varieties (and also by the close approximation of the germination energy to the final germination), emphasizes again the importance in practical farming of the use of well matured samples as seeds, and supports the finding of Scheibe (10) and of Jones and Tincker (6) that seedling vigour is influenced by the conditions under which the parent crop grew, and under which the seed was harvested.

Summary.

1. The suction-force of the seed has been shewn to be dependent largely on the environment under which the seed has developed.

2. Germination in sugar solutions furnishes a more rigorous test of seed vigour than does the germination energy.

Acknowledgments.

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THE BACTERIOLOGICAL EXAMINATION OF RAW MILK BY MEANS OF THE MILK AGAR PLATE COUNT METHOD.

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Hiscox and her co-workers have shown that the addition of milk to standard agar would convert it into a medium adequate

for many purposes for which, in its present form, it is unreliable (1). In the fourth edition of the *Guide to the Conduct of Clean Milk Competition* (2) the addition of 10 c.c. of sterilized separated milk to each litre of the agar is advocated. The examination of 265 samples of milk during the course of the Glamorganshire Clean Milk Competition—January to June, 1933—gave an opportunity for a comparison of the extent to which this modification of the standard agar plate count would affect the grading of raw milk.

The samples were received from thirty-four farms in 6 ounce bottles, and plated within 24-30 hours of milking on standard

TABLE I.

Series.	Month.	Time of Milking.	No. of samples.	Number of samples with bacterial counts less than 30,001 per c.c.		Number of samples with bacterial counts less than 300,001 per c.c.	
				On standard agar.	On "Milk agar."	On standard agar.	On "Milk agar."
1	January.	a.m.	32	23	20	27	25
2	February.	p.m.	36	26	28	31	29
3	March.	p.m.	34	20	19	27	24
4	March.	a.m.	31	24	22	29	26
5	April.	a.m.	34	12	12	25	19
6	April.	p.m.	34	18	15	23	28
7	May.	a.m.	31	6	5	19	9
8	June.	p.m.	33	10	8	14	12
	TOTALS		265	189	124	195	167

agar as well as on standard agar to which 1 per cent. sterilized separated milk had been added. Three plates of 1/10, 1/100 and 1/1000 c.c. dilutions were poured for each method, incubated at 37°C. for forty-eight hours and an illuminated chamber and talley counter used for counting colonies. Plates containing the nearest to 300 colonies were taken as being the most accurate.

Detailed results of the examination of each series of samples are given in Table I.

TABLE II.

	Series II. February p.m.				*Series VII. May a.m.*			
Code No.	*Temp. on arr. ° F.*	*Standard Agar. Count per c.c.*	*"Milk Agar." Count per c.c.*	*Relative Index S.A. = 100*	*Temp. on arr. ° F.*	*Standard Agar. Count per c.c.*	*"Milk Agar." Count per c.c.*	*Relative Index S.A. = 100*
1	51	20,800	22,110	109	53	54,000	95,000	176
2	48	17,000	38,000	194	54	276,000	147,000	58
3	49	5,800	5,000	86	53	5,600	15,900	284
4	54	1,500	1,000	73	54	160,000	187,000	117
5	54	170,000	190,000	112	54	124,000	226,000	182
6	54	120,000	160,000	133	54	13,000	11,000	108
7	51	400,000	360,000	90	53	4,100	3,000	73
8	55	5,800	6,100	115	55	165,000	240,000	145
9	55	600,000	720,000	120	—	1,680,000	2,000,000	119
10	51	200,000	540,000	270	—	—	—	—
11	53	140,000	360,000	257	—	—	—	—
12	55	2,100	2,500	119	54	20,000	8,000	40
13	49	11,900	15,800	133	55	360,000	452,000	125
14	49	11,800	13,800	117	—	—	—	—
15	53	8,200	27,000	329	54	228,000	240,000	105
16	54	240,000	160,000	67	54	380,000	940,000	247
18	47	700	810	116	54	12,400	10,000	823
19	49	800,000	880,000	110	55	700,000	864,000	123
20	55	4,500	5,000	111	53	1,900	2,000	105
21	54	3,600	4,300	119	51	187,000	150,000	240
22	51	630	720	114	53	120,000	245,000	204
23	54	21,000	32,000	152	55	380,000	472,000	124
24	49	12,000	14,300	119	55	160,000	830,000	520
25	53	3,300	6,500	197	55	872,000	1,500,000	172
26	49	7,400	7,500	101	—	—	—	—
27	47	11,400	14,500	127	51	55,000	700,000	1,270
28	—	3,400	4,800	141	55	220,000	1,200,000	545
29	54	1,600	1,800	113	57	640,000	720,000	112
30	49	164,000	250,000	152	56	380,000	640,000	168
31	51	7,600	10,000	132	55	156,000	728,000	465
32	54	23,200	27,400	118	54	92,000	130,000	141
33	54	1,200	1,000	83	62	160,000	820,000	512
34	49	11,000	15,000	136	57	568,000	816,000	142
35	56	7,000	28,000	400	61	230,000	314,000	136
19	54	310,000	720,000	232	—	—	—	—
7	52	270	350	129	—	—	—	—
9	—	—	—	—	55	760,000	850,000	112

These results demonstrate that the addition of milk to the medium had an appreciable influence on the colony count, and on the grading of the milk. The comparison of "milk agar"

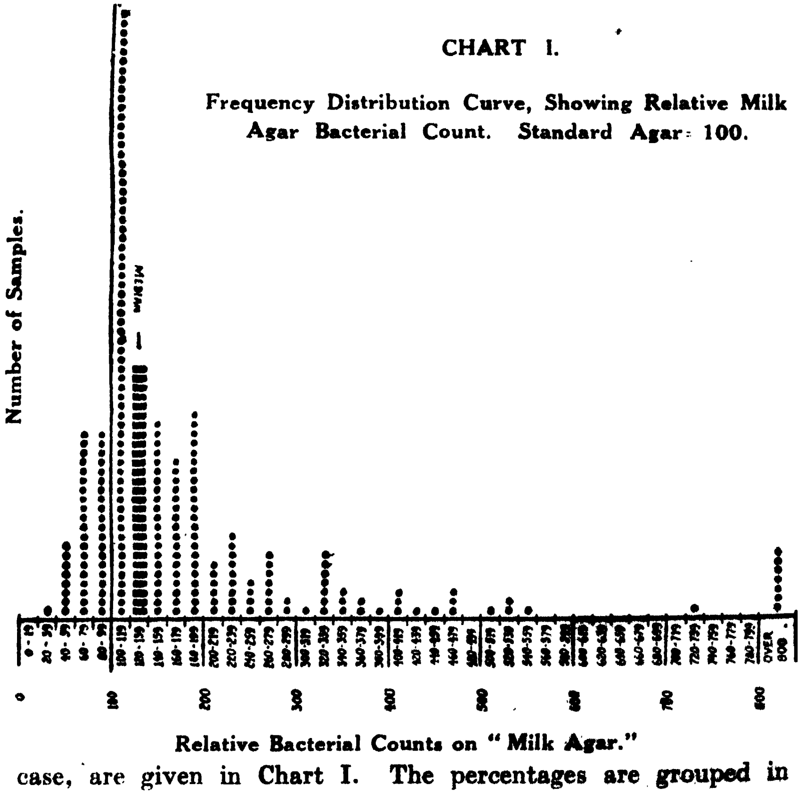
counts with standard agar counts shows that fifteen additional samples (5.7 per cent.) failed to attain the " Certified " standard, and twenty-eight additional samples (10.5 per cent.) the " Grade A " bacteriological standard. The general effect is less significant in this case than in the results of Hiscox, *et al*, on the comparison of the two media on 373 samples of pasteurized milk. These workers found that ninety-seven additional samples (26 per cent.) failed to reach the standard of a plate count of not more than 100,000 per c.c., when quantities ranging from 1/10th to 1/100th c.c. of sterile milk were added to each plate.

The actual plate counts obtained during the examination of two series of milk samples are given in Table II. These results illustrate the wide variations in the bacteriological quality of the samples tested. The relative comparison of the " milk agar " counts with standard agar counts reduced to 100 in every instance is also given.

The frequency distribution curve of all the results obtained, expressing the counts on " milk agar " as percentages of the counts on standard agar, when the latter are taken as 100 in each

CHART I.

Frequency Distribution Curve, Showing Relative Milk Agar Bacterial Count. Standard Agar = 100.



case, are given in Chart I. The percentages are grouped in twenties, for example, 100-119, 120-139, etc. It will be seen

from an examination of this chart that the majority of the samples (actually 81.5 per cent. of the total examined) show an increased count on " milk agar." The median is at 132 and is, therefore, within the possible limits of error of sampling, etc. (say 40 per cent.).

The number and percentage of samples in which the " milk agar " count showed an increase on the standard agar count are shown below :—

TABLE III.

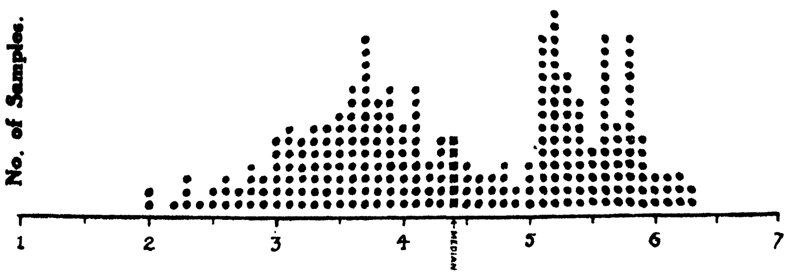
Total no. of samples tested.	*Number of samples for which the count on " Milk agar " exceeded the count on Standard agar by over :—*				
	1 per cent.	*40 per cent.*	*100 per cent.*	*200 per cent.*	*300 per cent.*
265	216 (81.5 %)	122 (46 %)	62 (23 %)	34 (13 %)	20 (7.5 %)

Thus the addition of milk to the standard agar medium had an appreciable effect on the bacterial count of approximately half the number of samples examined, 46 per cent. showing an increase in count exceeding the probable limits of error of

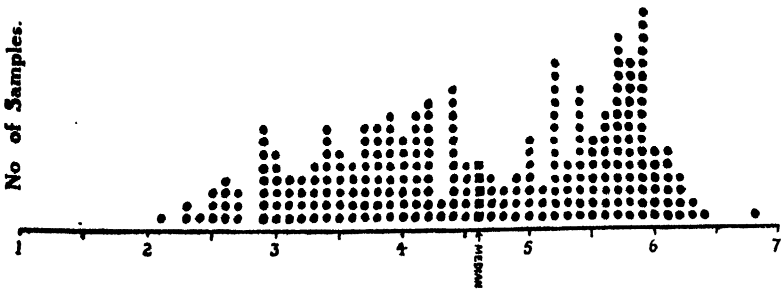
CHART II

Frequency of Logarithms of Actual Plate Counts.

Standard Agar.



MILK AGAR.



sampling. Only a small proportion (28 per cent.) showed an increase in count of more than 100 per cent.

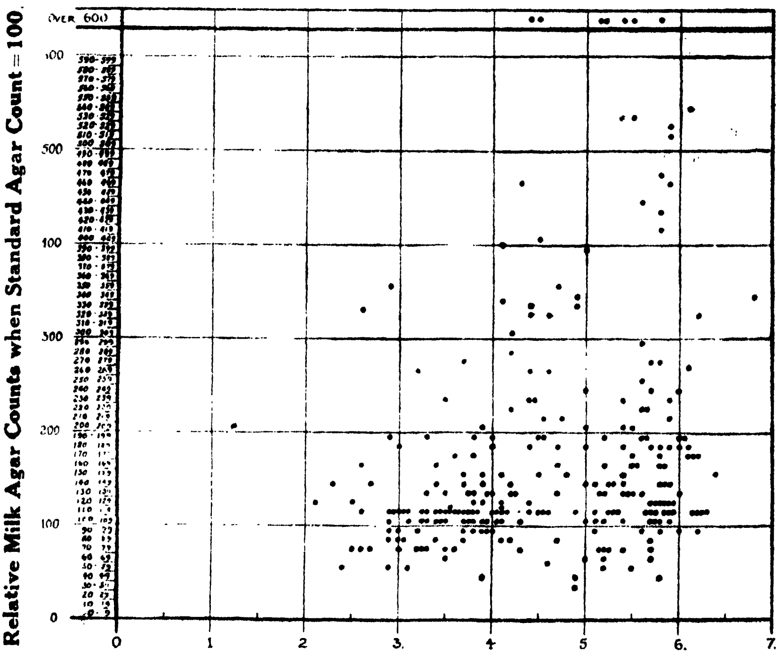
Logarithms of Plate Counts.

In Chart II a comparison of the bacterial counts on both media is again shown by plotting the logarithms of the actual plate counts. The milk agar results show an evident shift to the right.

Two peak points of concentration of samples can be observed in the standard agar curve, one at log 5.2. The milk agar curve, on the other hand, shows one marked concentration peak point and that at logarithms 5.7 to 5.9.

An attempt has been made in Chart III to demonstrate that the favourable influence of the addition of milk is more marked for those samples having high bacterial counts. An examination

CHART III.



Logarithms of Plate Counts on Milk Agar.

of the chart shows that the majority of the samples that show an increase of over 200 per cent. on milk agar as compared with standard agar, are situated between logarithms 4 and 6, *i.e.*, have bacterial counts from 10,000 to 1,000,000.

It seems, however, that the favourable influence of the addition of milk is closely connected with the types of bacteria

present in the various samples. In this connection it is of interest to observe that the milk agar counts for the last series of samples taken during June generally showed a more appreciable increase on the standard agar results than was the case during the series of samples examined during the colder weather. This may have been due to the presence of a higher proportion of lactic acid organisms in the milk flora during the warm weather.

The colonies developing on the milk agar plates were generally larger than those on the standard agar, and were thus easier to count. The presence of caseolytic colonies can also be detected.

Summary.

The addition of sterile milk to standard agar has a favourable influence on the number and size of the colonies that will develop during the examination of raw milk samples.

The increase in number, however, is not so significant as that obtained by other workers for pasteurized milk.

The use of " milk agar " for the routine examination of milk samples has resulted in a general tightening up of the bacteriological grading of milk.

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POTATO EELWORM DISEASE.

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In view of the serious losses caused by this disease in other parts of Great Britain, and of its rapidly increasing spread in many parts of Wales, it is thought that the following brief account of the life history of the causative agent, the symptoms of disease in the plant, and of such control measures as are so far known, will enable growers to recognise the disease when it first appears, and to take appropriate measures the following season.

Historical.

The eelworm (*Heterodera schachtii*), which has become such a serious pest of potatoes in Britain, has been known for many years in Europe and the United States. Its host plants number more than eighty, of which some are agricultural crops, others are garden crops, and many more are weeds. Originally known chiefly as a pest of sugar beet in Germany and America, where such severe damage occurred as to cause a wholesale closing down of factories, it was first recognised as being the cause of a potato disease also, in 1913. In Britain, the parasite was also first recorded on potatoes in 1913, but the probability is that it had already been present for some years, as it was stated to be common in Scotland. It was recorded again—in Yorkshire—in 1917, but there is little doubt that by that time it had succeeded in establishing itself in many districts in England.

In spite of the severe losses incurred, potato growing at that date (1917) was a very profitable undertaking, and potatoes continued to be intensively grown at a profit even on badly infested land. The result is that at the present date *Heterodera schachtii* is widely distributed throughout Great Britain, especially in the best potato growing districts, and the growers are in many cases sustaining severe losses. The distribution of this pest in Wales will be dealt with in greater detail later.

Life History.

This, fortunately, although it has many interesting aspects, is not at all complicated. Brown cysts, containing larvae, (young stages of the eelworm), are present in infected soil. When a potato rootlet comes in contact with, or in close approximation to, a cyst, a substance excreted by the growing root tip stimulates hatching, and the young eelworms burst their way out of the cyst and bore into the rootlets.

It is important to note that in the absence of this stimulus exerted by the root secretion, practically none of the cysts hatch. (This statement will be amplified later). The larvae do not burrow into the deeper tissues of the root, but remain just below the surface layers, where they feed for about three weeks, moulting once during that period. The subsequent development varies with the sex of the larvae. The male undergoes a quiesent period of about fourteen days during which it becomes mature. It then makes its way out of the root, as a typical elongated free-living worm.

The post-feeding development of the female follows very different lines. The internal organs, especially the ovaries,

increase rapidly in bulk, and the worm becomes swollen and flask shaped. This increase in bulk causes the surrounding root tissues to swell up, so that when the ovaries are mature, and ripe for fertilisation, the tissues of the root break down, and the swollen body of the female hangs outside the root to form a round cyst, while the head and neck remain embedded in the root. Fertilisation then occurs through the agency of the males which have by now become free living in the soil. After fertilization, the female degenerates until it becomes merely a cyst filled with developing eggs. This cyst, about the size of a pin's head, is at first creamy white in colour. It then becomes brown, owing to the secretion of a hard protective covering, and eventually drops off into the soil, where it remains until the following spring, when, in the presence of potato roots, the life cycle again commences.

Biological Strains.

A fact of great importance in the bionomics of *Heterodera schachtii* is that it shows a peculiar tendency to form what are known as biological strains. That is, although as stated above, its hosts plants number more than eighty, yet populations, or strains of the eelworm, become so specialised for a single host plant, or limited range of host plants, that they lose the power of attacking other plants. Thus evidence has been collected which indicates the occurrence in nature of (1) An *unspecialised* race able to attack a wide variety of plants; (2) A *beet* race which attacks plants of the beet and cabbage families; (3) A *pea* race which prefers members of the Leguminoseae; (4) The *oat* race which attacks cereals and grasses; and (5) The *potato* race which confines its attentions almost entirely to the potato.

The "Second Factor."

When the inflated potato prices which obtained during the war and immediate post-war years collapsed, the economics of potato growing became a very serious proposition, and the continued use of "potato sick" land for potato production was no longer a financial success. Impetus was thus given to research on potato eelworm disease both in the laboratory and in the field.

One of the facts that soon emerged was, that although the symptoms of potato sickness were never found to occur in the absence of the eelworm, the reverse did not hold good. That is, many fields were found with a high cyst content, which still

yielded normally good crops, and individual potato plants were found with roots bearing large numbers of cysts, and yet producing a normal yield of tubers. At the same time, and in the same district, fields having a lower cyst content were producing negligible crops, and plants bearing a comparatively small number of cysts gave a poor yield of tubers.

It was therefore evident that the presence of some second factor, in addition to the eelworm, was necessary before this particular potato disease could be produced. The nature of this second factor is still unfortunately unknown, but the problem is receiving much attention, and, broadly speaking, two views are now held :—

(i) That something inimical is present in the soil which operates in conjunction with the eelworm in producing the disease. This view is upheld by the fact that partial sterilization of the soil by steam or chemicals restores the fertility of the soil, although for one season only. Attempts to identify any fungus or bacterium as the second factor have so far failed.

(ii) That the second factor is lack of some ingredient essential to healthy growth, and especially to root production, which is not supplied by ordinary manurial treatment. This view is upheld by the fact that potato sick land may recover its potato fertility to a considerable degree after having been put through a short rotation.

The position is, however, by no means clearly understood. As has been stated, the disease never occurs in the absence of the eelworm, and there is ample evidence that a second, although as yet unknown factor, is also usually present. There is, however, also a certain amount of evidence which tends to show that the eelworm alone, without the interference of any second factor, may, under some circumstances, be sufficient to cause the disease. The situation is therefore somewhat obscure.

Symptoms.

The chief external evidences of attack on the roots are as follows. The sprouts are late in coming through the soil, growth is backward throughout the season, and the plants are poor and stunted. The foliage is dull and pale, and there is a tendency for the leaves to curl and wilt, and finally to fall off, causing the plant to have a spindly appearance, with a tuft of upper leaves. The leaves often show a progressive browning from the tip, along one or both sides of the midrib, and the margins become dry and inwardly rolled. The root system is much

reduced as compared with a healthy plant, and the tubers produced are few in number and small in size. In severe cases the crop does not pay for the lifting.

Method of spread.

Where the disease suddenly appears in a district hitherto free, it is undoubtedly introduced by cysts being embedded in particles of soil on seed from an infected area, or cysts mixed up with soil refuse at the bottoms of seed bags, or some such means.

Spread within a district can be carried out in a great variety of mechanical ways. Cysts may get carried by soil adhering to cart wheels, horses' hoofs, men's boots, borrowed implements, etc. In allotments, it is most important that a holder whose soil is clean should not borrow tools from those whose soil is potato sick, and even more important, that he should not walk over potato sick soil, or allow owners of such soil on his allotment.

Control.

Rotational.

As will have been realised from the foregoing account of the life history and bionomics of *H. schachtii*, the question of its control bristles with difficulties. The fact that the potato race of the eelworm is almost completely specific to the potato, suggests at once the adoption of a suitable rotation by means of which an interval of years occurs between successive crops of potatoes on any piece of infected land. This is strongly to be recommended on farms and large market gardens where soil and other conditions permit potatoes to take their place in the rotation, as, under a suitable rotation, land heavily infested with potato eelworm can still be made to carry profitable crops of potatoes. The beneficial effect appears to be due rather to a diminution of the second lethal factor referred to above, than to a reduction of eelworm cyst content of the soil, as although a small percentage of cysts die yearly in the absence of potatoes, it has been proved that cysts can remain in the soil for at least ten years, and still, given the necessary stimulus, be capable of hatching. The reduction of the second factor is however not permanent, and rotational treatment, giving at least three, and preferably more years rest from potatoes, should be continued.

In many parts of Great Britain however, and, unfortunately in some of the best potato districts, the land is unsuitable for other crops, and the adoption of a suitable rotation is a matter of great difficulty. In the smaller market gardens, allotments,

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and private gardens the matter also presents considerable difficulty, as usually at least half the area is under potatoes, which means that potatoes occupy the same land every other year. In these two cases, some means of control other than rotational must be searched for.

Manurial.

Evidence on manurial measures of control is very conflicting. In some cases, heavy dressings of farmyard manure in the drills at the time of planting the sets, have enabled good crops to be obtained on potato sick land, although the roots were heavily laden with cysts. On the other hand, in some of the worst potato sick areas, it is the common practice to apply heavy dressings of farmyard manure in the drills, and yet the crops suffer from sickness and poor yields are obtained. Complete dressings of artificial manures appear to be of no value in reducing sickness, but a heavy dressing of Calcium cyanamide appears to be beneficial.

Chemical.

Here again the evidence is of a conflicting nature. Very extensive research work has been carried out, particularly in Germany, and only one chemical — Calcium cyanide — has been found to be universally effective. The dressing necessary is so heavy however as to make the cost — about £300 per acre — entirely prohibitive.

The only other chemicals which have given any hopeful results and the cost of application of which is economically possible, are the various naphthalene by-products of the tar distillation industry, such as whizzed naphthalene, crude naphthalene, or drained creosote salts. Here again, however, the evidence is rather conflicting. In some cases good results have been claimed, in others, using as far as possible exactly the same procedure, no benefits have been obtained. Where increase in yield has been obtained, no significant reduction of the number of cysts has been observed. The increased yield may be due to some unknown way of interference with the second factor, or it may be due to a partial sterilization of the soil, this being a common cause of increased yield.

Laboratory experiments are still being carried out at various centres, in an attempt to find a cheap and effective chemical.

Other Control Methods.

Although the control measures now to be dealt with are still being carried out on a laboratory scale, or at the most on

small plots, some reference to them is necessary in order to complete this account. The first line of attack is that of attempting to discover the nature and mode of action of the second lethal factor involved. If and when this information is obtained, it may then be possible to evolve some means of counteracting the factor. The second method of approach is *via* the stimulating excretions of the potato roots. One series of experiments at present being carried out is to determine the exact chemical composition of the excretions. If this can be done, it is possible that the substance can be economically synthesised. The artificial product could then be applied to the soil and the cysts caused to hatch, when, in the absence of potatoes, the young eelworms would die. Much is expected of this method of approach.

It will be remembered that earlier in this account, the qualified statement was made that in the absence of the stimulating excretion of the potato roots, very few of the cysts hatch. Experiments have shown however, that the root excretions of certain grasses, notably the Rough and Smooth Stalked Meadow Grasses stimulate the larvae to hatch almost as freely as do potato excretions, and, what is extremely important, the young larvae do *not* attack the grass roots, but, in the absence of potatoes, die. On the field scale a reduction of about 30 per cent. in cyst content has been obtained by sowing these grasses, and experiments (which are still continuing), along these lines show much promise. It still remains to be shown however that land so treated is improved for potato growing in other ways, and the matter should still be regarded as being in the experimental stage.

Another line of approach which, while giving excellent results under laboratory conditions, failed in the field, is the use of mustard. In pot experiments, a great reduction in the percentage hatch of cysts was obtained by growing mustard in the same pot with the potato, these results being confirmed by several investigators. Unfortunately, growing mustard in the field and ploughing it in as green manure before planting the potatoes, appears to have no effect upon the disease.

Conclusions.

The foregoing account will have made it clear that the whole subject of Potato Eelworm Sickness and its control is still very obscure.

Without full knowledge of the true nature and cause of the disease, the difficulties attending all work directed towards its

control are enormously increased, but there is every hope that success will be achieved at any time now, along one or other of the lines of research now being followed.

Growers everywhere are urged to keep a keen look out for the first symptoms of eelworm attack on their potatoes, and to report to their County Authorities immediately, should they suspect its presence. Growers in the following districts are especially urged to keep a keen watch, as the disease is definitely known to occur in their area.

Distribution of *Heterodera schochtii* in Wales.

North Wales. The writer is indebted to Dr. Maldwyn Davies of the University College of North Wales for this information.

Caernarvonshire.—Edeyrn, Groeslon, Bangor.

Anglesey.—Aberffraw, Holyhead.

Denbighshire.—Denbigh.

South Wales. The writer is indebted to Mr. H. W. Thompson, of the University College of South Wales and Monmouthshire for this information.

Glamorganshire.—General throughout allotments, especially in Swansea, Neath, Port Talbot, Maesteg, Cardiff, Taffs Well, Treforest, Pontypridd, Troedyrhiw, Abercanaid, Aberdare and Caerphilly.

Mid and West Wales.

Cardiganshire.—Tregaron, Lampeter.

Pembrokeshire.—Haverfordwest, Pembroke.

Radnorshire.—Knighton.

Breconshire.—Brecon, Cefn Coed, Abercrave.

THE COCKCHAFER BEETLE, ITS INCIDENCE AND CONTROL.

By H. W. Thompson, M.Sc., F.R.E.S.,

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The Cockchafer Beetle (*Melolontha vulgaris* F.) is usually moderately plentiful in South Wales, especially in the rather heavily wooded areas of parts of Monmouthshire, and in certain years the Adult beetles are very numerous. Usually, however, the grubs of this beetle, which cause the bulk of crop injury, are not numerous enough to cause any very serious damage in the

area. During the summers of 1932 and 1933 an abnormal attack developed and very serious injury due to this pest occurred in North Monmouthshire, many growers suffering heavy losses in consequence. The following is a brief account of the outbreak and steps which were taken to combat it.

The most serious injury occurred in the Abergavenny district, and in the parishes of Llanellan and Llanfoist, where market gardening is carried out extensively. Most of the injury occurred on the low lying ground in the River Usk Valley but on one Hill Farm, ground over 600 feet high was very heavily infested. Vegetable and fruit crops were attacked as well as grassland, roots and corn crops. Moderately severe attacks to root crops and cereals occurred also in Mid and Central Monmouthshire in the Shirenewton and Caerwent districts. The Crown Nurseries near the Wye Valley in East Monmouthshire also suffered heavily and here in addition the smaller Garden Chafer (*Phyllopertha horticola* L.) was present and was responsible for some injury. In some beds almost all the seedlings of Spruce, Larch, etc., were reported destroyed.

The extent of the damage due to the attacks of chafer larvae is indicated by the following cases of injury met with by the writer on four typical farms and four market gardens in the districts most seriously affected. In addition, relatively light but by no means negligible attacks took place over a wide area.

1. *Market Garden.*

Total loss in 1932 of four acres of Spring cabbage, one acre of peas, half an acre of kidney beans, and heavy losses on other crops. This injury occurred following the ploughing up of grassland during the early winter of 1931 at this time the grubs were deep down and their presence was not suspected until injury began in the following spring. The loss on this holding was estimated as being at least £500.

2. *Market Garden.*

Three acres of strawberry plants were destroyed in 1932 and a partial loss occurred on all crops. The grower estimated his loss in 1932 as being in the region of £400.

3. *Market Garden.*

Three acres of cabbage and one acre of mangolds were a total loss in 1932 and 50 per cent. injury took place on one acre of potatoes. Extensive injury was also caused to

meadow land where the grubs were particularly numerous. In one field seventy-two grubs were collected from under one square yard of turf.

4. *Market Garden.*

Loss on general crop estimated at 20 per cent. on 30 acres or more. Young cherry and apple trees were killed by grubs at this centre.

5. *Farm.*

Two acres of mangolds were a total loss in 1932 and in the same year one and a half acres of potatoes suffered injury estimated at 50 per cent. In the autumn of 1932 old clover ley which was being broken up was found to be so heavily infested that ploughing was discontinued and the field left down.

6. *Farm.*

Failure of mangolds and potatoes in 1932. Less than half a crop of meadow hay due to chafer attack and a partial failure of oats. The meadow was so heavily infested and the root injury so extensive that over large areas in the field the turf could be stripped by hand or rolled back like a sheep's fleece. This field was rooted up by badgers in search of the grubs in the summer of 1932.

7. *Farm.*

Partial failure of mangolds and potatoes in 1932 and oats in 1933. Neighbouring farms were similarly infested.

8. *Farm.*

Partial failure of mangolds, oats and barley in 1932 and oats in 1933. Swede crops also infested.

At the end of 1932 examinations and collections made indicated that a fair proportion, possibly as many as 10% or more, of the chafers had reached the adult stage at that time and the majority of the remainder were likely to do so in 1933. Adult chafer beetles were moderately numerous in May and June of 1933 but their numbers were not excessive.

The fact that so many of the chafer larvae were still immature at the end of 1932 led one to anticipate similar injury in 1933 to that which had taken place in the previous year, and in the early

part of the summer there was every indication that these attacks would develop. Later on in the season, however, attacks dwindled and the numbers of larvae in the surface soil became greatly reduced. By digging more deeply many larvae could be found but they were sluggish and unduly yellow in colour. It seems possible that the abnormally dry summer of 1933 provided conditions too dry for the grubs which therefore left the surface layers of soil and by leaving their food plants became starved. During August and September, 1933, very few larvae could be found near the surface and these few mainly on headlands and other places where conditions were not so dry.

Previous Attacks.

Attacks of the severity indicated above have been rare in South Wales. During the eleven years the present writer has been in the area, slight attacks affecting a few acres only have been noted on potatoes, Whitchurch, Glam., in 1926, grassland, Caerwent, Mon. 1930 and slight attacks on cereals on several occasions in Monmouthshire. Growers in the Abergavenny area state that an attack comparable to the one described here took place in the district in the Jubilee year 1897. Davies (1815) gives a description of a similar attack in the Crickhowell area, a quotation from which may be of interest, as it indicates the extent and severity of this previous attack.

> "*The lightness of soil of this Vale occasioned an alarming effect, from the depradations of the pupae of the cock-chaffer in the wheat crops of the year 1810. The crops of the lighter soils about Crickhowell, etc., suffered most. About Abergavenny the soil was too dense for the operation of the insects; and above the town of Brecon their progress was not considerable, the intermediate space seems to have been their scene of action. A gentleman farmer on the spot, wrote and published a pamphlet on the subject; wherein he recommended to his neighbours, among other preventives, the trouble of collecting them by following the plough. His advice was not generally followed, but he himself procured the collection of three bushels and a half, of 40 quarts each, from a piece of 4 acres. In the spring of 1811, parochial meetings were convened to consult about the most effectual method of arresting their future progress, but before the opening of another campaign, the enemy fortunately decamped.*"

The attack described appears to have been similar in intensity to the 1982-3 attack in the Abergavenny area which is very near the same locality.

Life History.

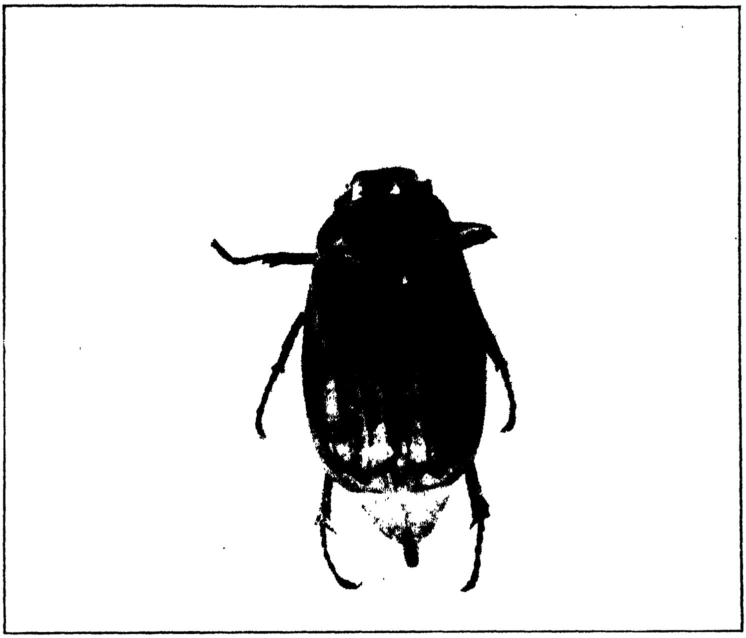
The female cockchafer lays her eggs early in the summer several inches below the surface of the soil, into which she burrows for the purpose and may lay as many as 70 eggs in all. The larvae hatch 5 or 6 weeks later, they are very small the first season and cause little injury, the following summer the grubs gnaw the roots of grasses and other plants and seedling trees. This feeding is continued during a third and fourth summer, the grubs are then full fed, they go down deeper into the soil and form oval cells inside which they change into a fleshy pupa, in which stage they remain for several weeks. The perfect beetles emerge about October but do not leave the ground until the following May.

Most of the cockchafers reach the adult stage in the same year, consequently every fourth year the beetles are more numerous than in the intervening years. The years when the majority of the chafers are in the adult stage are referred to as '*flight*' years. In these 'flight' years they frequently swarm in enormous numbers and cause much injury to Oaks, Chestnuts, Hazel and other trees and bushes on the foliage of which they feed.

The cockchafer beetle and grub are described in the Ministry of Agriculture leaflet No. 25 as follows :—

> "*The Cockchafer beetle (Fig. 1.) is about an inch in length with head and the front part of the body black, the wing cases being reddish-brown, hairy and with five raised lines on each. Along each side of the abdomen are five white triangular marks. The abdomen ends in a prolongation, downwardly curved, and not covered by the wing cases. The end joints of the antennae form a kind of club. The beetle is on the wing in May and June.*
>
> *The grub (Fig. 2.) is thick, fleshy and dirty white, the tail end of the body being swollen and in colour a dark purple brown. The head is large and brown, the mouth being armed with strong mandibles (jaws). There are three pairs of jointed legs on the front of the body. These white grubs lie with their bodies bent, and, although sluggish when taken out of the soil are comparatively active in it. Their length when full grown is about 1½ inches.*
>
> *The pupa is white, soft and easily injured and lies in a definite cell rather deep in the soil.*"

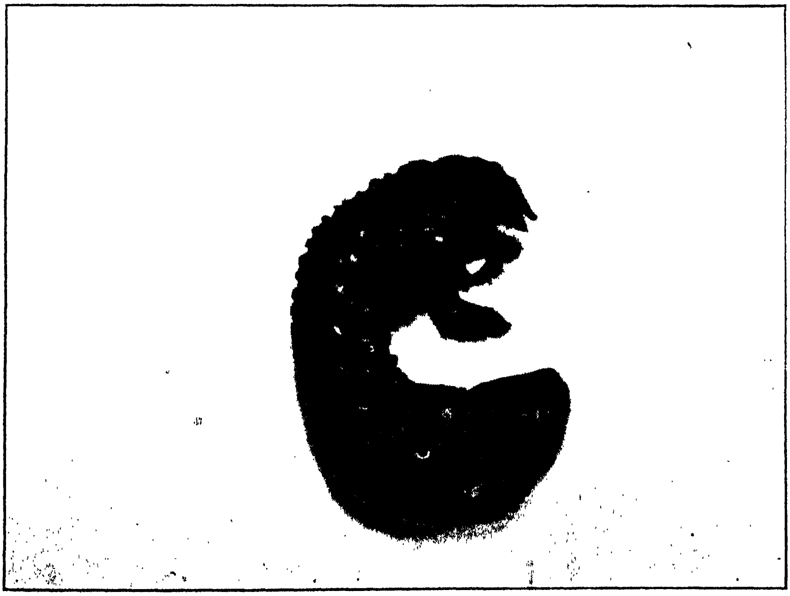
(Fig. 1.)



The Cockchafer Beetle (*Melolontha vulgaris* F.).

———|———|———|———|———|———|———|———|———|——— = 1.0 in.

(Fig. 2.)



Grub of the Cockchafer Beetle.

———|———|———|———|———|———|———|———|———|——— = 1.0 in.

General Observations in 1932 and 1933 on Overwintering Habits.

In 1932 chafer grubs were plentiful in the surface soil at the end of September, their numbers diminished in the soil to the depth of cultivation during October and by October 28 almost all the grubs had gone down for the winter.

On December 1, twenty-four larvae were found by digging to a depth of 1 to 1½ feet, also four adult beetles. On the same date several larvae were found at a depth of between 4 and 5 feet during drainage operations.

In the following spring, 1933, apparently none of the grubs returned to the surface before March, most of them were still deep down on March 17, although some were found on this date near the surface in a field down in clover ley. By April 20, apparently all the grubs had returned to the surface soil and were once more attacking the crops.

Control Measures.

It has been recognised for some time that Naphthalene is an insecticide capable of destroying chafer grubs under certain conditions but it is not effective in all cases. It was decided therefore to try applications of this material to infested ground at varying rates per acre and at different times of the year, in an endeavour to gain further information on the subject. All the growers approached were very willing to co-operate in these tests. Unrefined Naphthalene, commonly known as Drained Creosote Salts, was used in most cases and suitable material was obtained from the big Colliery Companies at about 5s. to 7s. per cwt. It was realised that Naphthalene must be washed well into the soil to be effective, especially when surface applications are made, and consequently all tests carried out were made in showery weather. Unfortunately the abnormal drought of the summer of 1933 upset some of the tests. It was observed on a number of occasions that even when the surface of the ground was wet the soil was perfectly dry deeper down. Consequently only the surface soil was likely to be affected by the dressing.

Tests of Naphthalene.

Centre 1. *Market Garden.*

A five acre plot of heavily infested land was dressed by the grower with Naphthalene, which was worked in, at the rate of 6 cwt. per acre on August 28, 1932, and was planted out with Spring Cabbage ten days later. The plot was examined on October 10, there was at that time no evidence of chafer injury. The Naphthalene caused little injury to the plants, they showed

some blueness at first and were rather slow in establishing themselves but recovered well. This application gave almost complete control of the chafer grubs, not more than 1% of the plants failed as a result of their attack. It was estimated that over 90% of the grubs were killed and very few could be found when the plot was ploughed out the following spring.

A plot of three acres where cabbage failed completely in 1932 was dressed with Naphthalene at 6 cwt. per acre on April 21, 1933. The application was followed by heavy rain. The plot was examined on May 3 and approximately 50% of the larvae found were dead on this date, many were lying on the surface in a blackened condition and many others appeared moribund. The plot was given a further dressing of 5 cwt. per acre by the grower on May 5 " to make sure ". Potatoes were planted on May 11 and comparatively few grubs were collected on rowing up. The crop was examined when lifted on September 19, 1933 —the amount of injury was negligible—three tubers only were noted to be injured on one row nearly 300 yards long, and the men engaged in lifting stated that they had found only six grubs on the plot.

Centre 2. Farm.

On May 29, 1933, a test plot on meadow land was dressed at the rate of 8 cwt. per acre, which was followed by a light thunder shower. Larvae were present to the average extent of 7 per square yard. This plot was examined on June 19, the treated turf was scorched by the application. Several moribund grubs were found on the dressed portion but none at selected points of the untreated part of the field. The surface soil was damp, below that 6 inches or more was very dry—apparently the grubs had gone down because of the drought, except those injured by the application. Naphthalene was also applied at the same rate on mangolds but owing to drought conditions prevailing during the summer the grubs caused very little injury to the mangolds and little information was available as to the proportion of grubs killed.

Centre 3. Market Garden.

On May 25, 1933, a test plot was established on grassland. Whizzed Naphthalene at a cost of 12s. per cwt. was applied at the rate of 8 cwt. per acre—a very heavy thunderstorm washed the Naphthalene in. On this field 72 grubs had been collected from under approximately one square yard of turf.

The plot was examined on June 2. No living larvae were found from areas examined on dressed plot—42 dead were collected.

A second test plot of ¼ acre on ground being prepared for cabbages was also put down on May 25. On this plot swedes were a complete failure in 1932. A thunderstorm washed the napthalene in—this material was rather moist and after the rain formed a soapy scum which persisted for several hours on the surface of the ground.

This plot was examined on June 14th—all the grubs found were dead while, on the neighbouring untreated cabbage plot numerous healthy grubs were found attacking the plants.

Centre 4.

Applications at the rate of 2½ cwt. per acre were applied during a showery period on infested beds of young strawberry plants. The Naphthalene was worked into the soil along the rows but owing to drought conditions following the application the grubs left the plants and no results were obtained.

A Soot Application.

At one centre two acres of peas failed owing to chafer attack in 1932 and before ploughing in the crop the grower applied soot at the rate of 25 cwt. per acre. This dressing was as far as could be ascertained quite successful in destroying the grubs and in the following Spring the plot was found to be practically clear of them, only about a dozen being noticed during cultivation.

Hand Picking.

At centre 1—grubs were collected from a one acre plot on which peas failed in 1932. Two boys followed the plough and gathered a total weight of 110 lb. This figure represents about 21,000 grubs per acre. In addition to this number many would not be exposed by ploughing and many were also picked up by birds. In all, hand collection following the plough was carried out on about 15 acres on this holding and in no case was there chafer grub injury to subsequent crops.

At all the market gardens infested with chafers, hand picking of the grubs was carried out, and it seems clear that this practice is the most suitable to follow under market garden conditions when the land is cultivated during the summer. Even when Naphthalene at as low a price as 5s. per cwt. is used it is more expensive to apply and less sure in its action than hand picking.

Birds.

Birds played quite a considerable part in reducing the numbers of chafer grubs and during cultivation collected very many of them. During Autumn cultivation particularly, Gulls visited some of the infested fields in very large numbers, and on other occasions Rooks and Starlings followed the plough and carried off many of the exposed grubs.

Conclusions.

From observations made it seems clear that Naphthalene at the rate of 5-6 cwt. per acre will give control of chafer grubs when applied in the early autumn, and that satisfactory control of the grubs can also be obtained by summer applications when the material can be worked into the ground, or when there is sufficient rain to wash it well in.

On infested land ploughed up between April and September, when the grubs are near the surface, the most economical and effective control measure would appear to be hand collection during cultivation.

Where turf known to be infested cannot for some reason be ploughed up until late autumn a Naphthalene dressing might with advantage be applied in September before the grubs go down for the winter.

With regard to the control of the grubs on grassland, control was obtained on the test plot at one centre by a dressing of 3 cwt. per acre, at another the test failed owing to the abnormally dry weather conditions.

It seems advisable that where Naphthalene dressings are resorted to, applications of 5 or 6 cwt. per acre should be given. In one case on grassland and one on arable land control was obtained by applications at half that strength, in each of these two cases however exceptionally heavy rain followed the application and may account for the satisfactory result.

It appears that a heavy dressing of soot may also be effective as a control measure.

REFERENCE.

DAVIES, W. General View of the Agricultural and Domestic Economy of South Wales, Vol. 1, 1815.

PRELIMINARY NOTE ON GRASS DISEASE INVESTIGATION IN SOUTH-WEST WALES.

By D. C. Lloyd, B.Sc.,

University College, Aberystwyth.

In spite of a considerable annual loss of horses due to Grass Disease in South-West Wales, little attention, at least on a co-operative basis, seems to have been given to the outbreaks

The disease, which almost invariably occurs only in horses which have access to growing grass, was first recognised in Scotland in 1909. There it has spread inland from North East Angus to Perth, north to Aberdeenshire and other counties, and south to Northumberland. Sporadic cases have been noted in south-east England and the Severn Valley.

In 1922 the disease became established in St. Dogmells, Pembrokeshire. It has been confined almost exclusively to the south of the river Teifi, and is most prevalent in the St. Dogmells, Moylgrove and Eglwyswrw districts. Since 1928 it has spread into Carmarthenshire. No cases have been noted in other parts of Wales.

Most of the work on the disease has been carried out at the Animal Diseases Research Institute, Moredun, Scotland, and the following account is largely based on their efforts.

Conditions of occurrence.

Outbreaks occur on the most varied pastures, usually about two weeks or more after the horses have first been put out to grass, but often after a change of pasture.

Maximum incidence thus occurs in May and June soon after the horses have been turned out, falling to a minimum in September, while there are a few attacks during autumn, winter and early spring on pastured colts (this seems to be rarer in Wales). Evidence as to the associated weather conditions is conflicting.

Outstanding features of the disease are first, its erractic appearance in the affected locality; thus in the Moylgrove district, interspersed among the affected farms, are ones which have suffered no loss, though no environmental differences can be detected; and, secondly, there is considerable evidence to show that even on affected farms, the infective area may be limited to one or two fields, the remainder of the farm being safe.

Symptoms.

The symptoms of the disease are sufficiently well known not to need detailed description. There is a loss of appetite and bowel movements are sluggish, becoming completely inactive in acute cases. There is frequent difficulty in swallowing and a continuous and progressive depression.

Post-mortem examination in acute cases, shows the stomach to be markedly distended with fluid, the small intestine normal, while the large is impacted with hard dry excreta.

In sub-acute cases the stomach is not distended and the intestines are relatively normal.

Etiology.

Extensive work at the Moredun Institute has failed to demonstrate the casual agent. No plants other than common pasture and weed plants, together with their associated fungi, have been discovered on infected pastures. Feeding with these has proved negative, as has also feeding of faeces from infected animals.

There is no evidence that the disease is contagious nor have pathological organisms been demonstrated in the tissues, and there is no indication of a protozoan or filterable Virus being the cause.

Mode of Transmission.

The disease is apparently not contagious or infectious. In Scotland it has been found to spread in the teeth of prevailing wind, and to be checked by a broad stream or river. Recently a possible correlation with the Springtail *Sminthurus viridis* has been suggested.

It has been noticed that the areas of maximum incidence of the Sminthurus sometimes coincide with the areas affected with Grass Disease, and that Pembroke is one such locality.

A study of the incidence and habits of the insect and the conditions of occurrence of the disease showed the following relationships (Moredun).

The Springtail is pre-eminently a clover feeder and since the introduction in Scotland in 1915 of Wild White Clover, the insect has rapidly multiplied and the disease rapidly increased.

Wind and rain reduce the population of Sminthurus on the plants, while wet windy weather causes a decline of Grass Disease. In Wales it is maintained that the reverse holds, outbreaks being frequent after sudden rain following a dry spell.

S.viridis has two seasonal optima—May-June, and September and accurs in small numbers throughout the year. The second maximum thus coincides with minimum incidence of the disease but this does not exclude the possibility of the Springtail being a vector.

Close grazing by sheep very markedly reduces the population of *S. viridis* and the practice of sheep grazing appears to have been of some preventive value.

Spread of Sminthurus and also of the disease is checked by a broad stream or range of hills

S. viridis is both a soil and leaf feeder and thus it may contaminate certain plants with soil organisms.

However, numerous sweepings of Sminthurus and other insects administered to horses during the Grass Disease season failed to give any definite symptoms.

On a suggestion from Scotland, the writer, under the supervision of Mr. J. R. W. Jenkins, Advisory Zoologist at the University College of Wales, Aberystwyth, has commenced an investigation into the incidence of *S. viridis* in affected and unaffected areas, and the opportunity has been taken to include a general seasonal survey of the Arthropod fauna of the grassland of the district also.

The absence, after years of experimental work, of any definite clue as to the casual factor, seems to indicate that an intensive ecological survey involving co-operation of chemist, botanist and zoologist would be fruitful. To this end the writer is collaborating with Professor Fagan, who has made chemical investigations in the affected localities, with the Agricultural Botany Department of this College, and with Mr. N. Bisset, Adviser in Veterinary Science, University College, Cardiff.

ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

ANIMAL NUTRITION.

Abstractor:

R. O. Davies, M.Sc., University College, Aberystwyth.

Animal Nutrition; Methods of Experimentation in.

George Dunlop. *J. Agr. Sci.* (1933), 23, 580-614.

The merits and drawbacks of different methods in animal feeding experiments are discussed. A new method involving individual rationing, and random distribution of the animals for statistical analysis of the results is described. R.O.D.

Artificially Dried Grass; The Influence of—in Winter Ration of the Dairy Cow on the Colour and Vitamin A and D Contents of Butter.

S. J. Watson, J. C. Drummond, I. M. Heilbron, and R. A. Morton. *Empire Journ. of Expt. Agr.* (1933), 1, 68-81.

By the inclusion of a sufficient proportion of artificially dried grass in the winter ration of the dairy cow it has been possible to produce butter which, in regard to colour and vitamin A content, is equal to the butter produced in summer from grass fed cows. R.O.D.

Beef Production; Relative Values of Swedes, Potatoes, Dried Sugar Beet Pulp and Silage in.

W. G. R. Paterson. *Trans. Highl. and Agric. Soc. Scot.* (1933), 45, 23-45.

The following results were obtained from three experiments carried out at Auchincruive:—

(*a*) 40 lb. potatoes per head per day could be safely and efficiently fed to cattle with no adverse effect on the quality of flesh.

(*b*) In a fattening ration containing 72 lb. swedes all or part of the roots could be adequately replaced by beet pulp. 12 lb. of dried sugar beet pulp replaced the full 72 lb. swedes and when fed in three feeds of 4 lb. could be safely fed dry.

(*c*) The results of comparing sugar beet pulp and silage on a dry matter basis showed a slight advantage for the beet pulp, but it was noticed that the greater bulk of the silage ration led to a decreased hay consumption. R.O.D.

" Cripples " in Lambs.

W. L. Stewart. *Vet. Rec.* (1933), 13, 109-12. (Armstrong Coll., Newcastle-upon-Tyne).

" Cripples " is a disease of lambs occuring on permanent pasture grazings. Lambs from one to two weeks old are most susceptible. Both the calcium and inorganic phosphorus of the body of affected lambs are subnormal. The possible relationship of the condition to pasture mineral deficiency is discussed. R.O.D.

Dairy Cows; Fish Meal versus Cottonseed Meal as a Feed for.
INGHAM, L. W. *Univ. Maryland Agric. Exp. Sta. Bull.*, No. 342.

The result of the feeding trial indicates that there is no difference between the two meals as a source of protein in the rations of dairy cows. Costs would be the deciding factor. No bad flavour or odour was detected in the milk when fish meal constituted about 13 per cent. of the production ration. R.O.D.

Fattening Sheep; An experiment on the Food Consumption of.
J. A. S. WATSON, D. SKILBECK, J. C. B. ELLIS. *Empire Journ. of Expt. Agr.* (1933), 1, 165-72.

An experiment is reported which confirms the view that the curve of " average dry matter consumption " for the fattening sheep now generally used in this country, gives values that are substantially too high. It is suggested that true curves for normal dry matter consumption should be based on a figure of 3 lb. per 100 lb. live weight per day when the ration consists mainly of air dried foods of high palatability, fed in reasonable variety and *ad. lib.*; and that the normal consumption on the typical British ration is about 2.6 lb. per 100 lb. live weight per day. R.O.D.

Lucerne; Nutritive Value of. 1. Preliminary Studies.
H. E. WOODMAN, R. E. EVANS, and D. B. NORMAN. *J. Agr. Sci.* (1933), 23, 419-58.

Details are given concerning yield, composition and nutritive value of lucerne crops in different localities during 1932. The results of the digestion trials show that the lucerne both in bud and flower was very distinctly inferior in digestibility and nutritive value to pasture herbage. This difference in digestibility was particularly marked in the case of the fibre, which in pasture herbage is non-lignified and of high digestibility, but in lucerne is woody and of low digestibility. Further investigations are in progress.

R.O.D.

Mineral Metabolism; Studies in.
18th Rep. Director Vet. Services and Animal Indust., Union S. Africa (1932), 703-32.

A study was made of the absorption of calcium and phosphorus by bovines with varying $CaO : P_2O_5$ ratios in the diet. The calcium eliminated via the kidneys increased when the ration was low in phosphorus. The addition of sodium phosphate to a ration low in phosphorus influenced the absorption and retention of calcium favourably. The addition of calcium carbonate to a ration low in phosphorus reduced the absorption of phosphorus. R.O.D.

Palatability; The—of the Self Establishing Species Contributing to Different Types of Grassland.
W. E. J. MILTON. *Empire Journ. of Expt. Agr.* (1933), 1, 347-60.

The relative palatability of miscellaneous herbs, grasses and clovers on widely differing types of grazing land is given.

The relative palatability of the miscellaneous species was approximately the same for each type of grazing land examined; but the grasses

showed variation, chiefly due to stage and type of growth and the presence of burn.

The importance of the miscellaneous herb group in terms of relative productivity and amount eaten is indicated, and the mineral and dry matter contents are discussed. R.O.D.

Poultry Feeding; Bulkiness of Food as a Factor in.

T. Shaw, E. A. Fisher. *J. Min. Agr.* (1933), 40, 327-37.

The work described demonstrates that the undoubted bulkiness of dry bran is no detriment to its use in considerable proportions as a constituent of poultry mashes. It is the bulkiness of the ration which must be considered, not that of the individual foods composing it. The bulkiness of bran is in no way abnormal when the bran is fed in combination with other foods, *i.e.*, in mashes. R.O.D.

Preserving Fresh Fodder; The A.I.V. Method of.

A. I. Virtanen. *Empire Journ. of Expt. Agr.* (1933), 1, 143-55.

The discovery and theoretical basis of the A.I.V. method is discussed, together with the physiological effect of the fodder on animals. Experiments with mixtures of hydrochloric and sulphuric acids showed that small amounts of sulphuric acid have a favourable effect on the functions of the intestines, and at the same time are physiologically quite harmless. The A.I.V. solution in use at Helsingfors over the last four years has invariably contained a small amount of sulphuric acid in addition to the hydrochloric acid. Feeding trials with fodder preserved solely with sulphuric acid, showed that this acid cannot be used alone. R.O.D.

Pullet, The Nature of the Calcium and Phosphorus Combination in the Excreta of the non-laying.

F. Knowles, J. E. Watkin and F. W. F. Hendry. *J. Agric. Sci.* (1933), 23, 196-203.

Metabolism experiments were carried out on three rations differing only in the amounts of calcium and phosphorus supplied in various combinations. The data obtained indicate that in the case of a ration containing adequate amounts of calcium carbonate, the normal form in which phosphorus is excreted by the non-laying pullet is as dicalcium phosphate, any excess of calcium over that needed for its formation being excreted as calcium carbonate. R.O.D.

Potatoes and the Pig.

T. S. Wright. *J. Min. Agr.* (1933), 40, 605-11.

The results of the feeding experiment indicate that for satisfactory feeding cooked potatoes should not be included in rations for pigs under four months old, after which they can displace one third of the starchy foods until the fifth month when, if desired, the proportion can be gradually increased to a limit of two-thirds. Beyond that amount the feeding of ware and seed potatoes would appear to be uneconomic.

R.O.D.

Sheep Sickness of Permanent Pasture.

E. J. Roberts. *J. Min. Agr.* (1933), 40, 337-43.

Observations are made on a condition of lambs often said to be due to their grazing "sheep sick" land. Whether this condition is caused by parasitism or by a nutritional defect is not determined.

R.O.D.

Stomach Worm; The Influence of the Nutritional State of the Sheep on its Susceptibility to Infestation with.

A. H. H. Fraser and David Robertson. *Empire Journ. of Expt. Agr.* (1933), 1, 17-21.

An experiment was carried out to determine the effect of nutritional states on the degree of parasitic infestation of sheep exposed to an equal chance of infection. The results show that well fed lambs have a higher degree of resistance to infection than those poorly fed.

R.O.D.

Sterility in Farm Live Stock.

A. D. Buchanan Smith. *Scottish Journ. Agr.* (1933), 282-93.

The principal factors which cause sterility are discussed, and the effect of nutrition on the fertility of farm stock is dealt with. An otherwise balanced ration may be deficient in one substance requisite for fertility. The deficiency is most likely to be phosphorus, calcium, vitamin A, vitamin E or an animal protein. It is also possible that the excess of a specific substance can also lead to sterility. In addiiton to the direct influence of diet on fertility there is also the indirect effect through its modifying action on susceptibility to infection. R.O.D.

Sows and Litters; Feeding of.

W. A. Stewart. *J. Min. Agr.* (1933), 40, 169-73.

The rationing of sows and litters is discussed in the light of recent experience and the renewed interest in pig-breeding. R.O.D.

Wool Growth; Variation in the Protein Intake of Sheep in Relation to.

A. H. H. Fraser and J. A. Fraser Roberts. *J. Agr. Sci.* (1933), 23, 97-107.

Two lots of twenty sheep each were fed indoors on rations known to produce satisfactory growth. One lot was fed on a protein deficient ration, while the other lot received 52 per cent. more digestible protein. There was no significant difference between the two groups in respect of any of the wool characteristics measured. The high proportion of wool produced by the low protein group in comparison with the amount of digestible protein fed makes it probable that synthesis of cystine occurred. It is suggested that this synthesis may be a special function of the wool follicle. R.O.D.

Whole and Separated Milk; The Relative Value of—fortified with Tapioca or with plant oils and cod liver oil.

37th Rept. Inst. Animal Nutrit. Roy. Agric. Coll., Norway (1933).

The results of several years' experiments on pigs and calves to study the effect of replacing the fat of whole milk by carbohydrate or other fats are summarised and discussed. The basal rations for pigs

W.

was of cereals, for calves of hay. Replacement of milk fat with tapioca of equivalent energy value was found to give very satisfactory results with both pigs and calves. There was no indication of deficiency of fat soluble vitamins on the tapioca ration. R.O.D.

GENERAL.

Abstractor:

Professor R. G. STAPLEDON, C.B.E., M.A., Welsh Plant Breeding Station, Aberystwyth.

The Empire Journal of Experimental Agriculture.

The number of journals dealing with agriculture and agricultural science is already considerable, and to this number has now been added the Empire Journal of Experimental Agriculture.

The new Journal is, however, cordially to be welcomed on many grounds. As the title suggests, it deals more essentially with experimental agriculture, with field trials, agricultural practice and livestock, rather than with laboratory researches. The Journal addresses itself to the agricultural problems of the whole Empire, and articles are contributed by overseas workers as well as by those in Britain. The Journal is published by the Oxford University Press, and has a particularly representative Editorial Board—representative from the point of view both of subjects and of the different countries of the Empire.

The Journal is published quarterly at 7s. 6d. a number, and the first issue appeared in April, 1933.

The thirty-seven articles published in the first volume cover a wide field. Of particular interest to workers overseas we may note " The Manuring of Tea " and " The Residual Values of Leguminous Crops." Perhaps of chief interest to workers in Wales are the three articles dealing with sheep problems, and those devoted to various aspects of the management of grassland.

Under this latter heading Welsh readers will be particularly interested in a series of papers contributed by Mr. M. G. Jones (formerly on the staff of the Welsh Plant Breeding Station). By carefully controlled experiments Mr. Jones has demonstrated the magnitude of the effect of the grazing animal in controlling the botanical composition of the sward.

The new Journal has undoubtedly set itself a high standard, and it can definitely be said to have taken its place with the important Journals devoted to agricultural science, and all the indications are that it will cover a field that has not adequately been catered for by other and more specialistic periodicals. R.G.S.

LIVE STOCK.

Abstractor:

A. D. BUCHANAN SMITH, M.A., B.Sc., F.R.S.E., Department of Animal Genetics, University of Edinburgh.

Artificial Insemination; The Technique of.

A. WALTON. *Imperial Bureau of Animal Genetics*, with Introductory Chapter (1933), Edinburgh, Oliver and Boyd, Price 2s. 6d.

The progress recently made, particularly in Russia, with methods of artificial insemination is striking. The greater part of the work has

been published in foreign languages. We are greatly indebted to the Imperial Bureau of Animal Genetics for bringing together in a concise manner the present status of our knowledge on this subject.

The Introductory Chapter is written by Dr. Walton, of the Cambridge School of Agriculture, who has had more practical experience than anybody else in this country. He treats, in an interesting manner, the physiology of artificial isemination, and this account is full of fascinating information. Why, for instance, are so many spermatoza liberated by the male? Are they essential or do they merely represent a superfluity? Dr. Walton points out that an increase in the number of spermatoza present increase proportionally the number of active cells *at any given time;* hence an increase in the number of spermatoza increases the effective duration of the sample.

As regards the survival of fertility of the spermatoza outside the body, Dr. Walton states that a reduction of temperature is perhaps the most important factor, but that the exact optimum of each animal must be worked out in detail. Dilution is also important, and likewise the semen must be protected against exposure to the air.

The next section of the book deals with the Technique of Artificial Insemination, and should be studied in detail by anybody desirous of applying it. There is a Chapter on the application of artificial insemination in stockbreeding practice from which the following are taken. In Russia at one collective farm 170 cows were inseminated once each with one dose of undiluted sperm. The percentage of "settling" was 81.2 per cent. With one dose of diluted sperm (1 : 1) 1,351 animals were inseminated, and 87.6 per cent. of this number settled to the service. As many as 1,000 and more calves have been obtained from one bull. There are no technical obstacles to prevent 1,200-1,500 calves being sired by a single bull during a sixty days' breeding season. The principal obstacle is one of organisation.

At the present moment the Russians find it possible to inseminate with sperm from a single mating of the best imported rams no less than fifty ewes which is, taking two matings per day, 4,000 ewes for a season of forty days. The rate at which cross-breeding and grading up may be carried out is thus enormously increased. The Sheep Breeding Trust of Russia subjected 96,000 ewes to artificial insemination in the year 1931.

A good Bibliography is attached.

A.D.B.S.

Conformation and Milk Yield in Friesian Cows; A Study of Some Points of.

F. H. Garner (1932), *J. of Dairy Res.*, Vol. 4, pp. 1-10.

Preliminary work was done on 500 recorded Shorthorn cows in Berkshire. but these figures had to be rejected owing to the difference in dairy and dual purpose types of the breed. Accordingly the writer made afterwards measurements of pedigree and grade milk recorded Friesian cows of a uniform type, found near St. Paul, Minnesota. The figures particularly refer to fifty-seven cows, all of which were over four and a half years of age.

The milk yields were taken as produced by the cow, but all cows that had been in milk for more than 365 days were eliminated, and finally the total number of cows measured was 461.

The writer found that it was important that a cow should have a long body; the correlation here was not much, but significant. He found that the height of the hindquarters of the cow was more highly correlated with milk yield than the height of the forequarters. The coefficient of correlation between yield and width at the hooks was also significant, and bears out the opinion of judges who prefer a cow with a large pelvic girdle.

With regard to constitution, a significant correlation was obtained between the circumference of chest and milk yield but not between depth and width of chest, though the writer concludes that these last two measurements could not be so accurately made as the first. "Capacity" was measured by the width of barrel at the thirteenth rib and by the circumference of barrel and again a significent correlation was obtained, namely + .27 in respect of circumference of barrel.

Concerning those measurements indicating mammary development, the writer points out that the blood leaves the udder by six different veins and that only two of these, the so-called milk veins, are visible. Where the veins turn suddenly upwards, some 6-12 inches from the fore-legs, the milk wells are produced. The question arose as to whether the milk wells were larger on bigger cows not because of higher milk yields but to be proportionate to the frames of the cows. It was found that the size of the cow did not materially influence the size of the milk well. Measuring size by the height at the hooks and holding this figure constant, a positive correlation was obtained between size of milk wells and milk yield of + 0.85. The writer concludes that the total area of the milk wells is thus an excellent indicator of their milk producing ability. Usually a large milk well will take the tip of the middle finger of a normal man, and although one would never attempt to judge a cow by one point alone, the size of the milk wells is probably the best single point indicating milk producing ability. It is further stated that there may be a close relationship between the size of milk wells in parents and the milking capacity of their daughters.

A.D.B.S.

Conformation of the Cow as Related to Milk Secretion.

J. W. GOWEN. (1933). *J. Agric. Sci.*, Vol. 23, pp. 485-513.

Conformation of the Parents as Related to the Milk Secretion of the Daughters.

J. W. GOWEN. (1933). *J. Agric. Sci.*, Vol. 23, pp. 514-8.

In these papers the writer has brought to fruition a study upon which he has been engaged for the past ten years.

A striking feature is the marked influence of the weight of the cow on her milk and butterfat production as contrasted with the other elements of type. The other measurements making up type when combined appear to have an influence equal with weight on the milk production or butterfat yield of the cow. The body measurements which were taken—height at withers, depth at withers, heart girth, paunch girth, width at hips, body length and rump length—are dependent upon the skeletal development of the cow. Weight takes into account not only the size of these bones but also the amount of flesh which is on them. A difference is thus to be expected between the relation of weight to production and of the type measurements; such a difference was

obtained. It would appear that not only the size of the cow as determined by her skeleton, but also the degree of fleshing which she carries, has a pronounced influence on her productive capacity.

If, however, the measure of worth is to be the relation of energy intake of the food the animal consumes to the energy found in the milk produced, then the effect of weight on quantity of milk produced seems to be offset by the extra energy necessary to maintain this weight.

The writer says that the cow's conformation is, on the whole, a rather inferior means of predicting future milk producing capacity. From a production standpoint the significant items in mature form conformation or type are—the size of cow, the size and characteristics of the udder and milk veins, and the wedge-shaped form characteristic of dairy cattle. The writer states that he is not in favour of neglecting the information that a study of conformation can give, since it has one real advantage in that it shows the present status of the cow's physical health, and whether the mammary gland is physiologically normal.

In the second paper, which, like the first, deals with Jerseys in the American Registry of Merit, it is found that there was no outstanding relation between the conformational measurements of the sire and the production of his daughters. The weight of the sire appeared to have a slight importance in indicating what the daughter's probable production would be in milk and in butterfat yield. From these facts the writer draws a tentative conclusion that the sire should be of good weight to produce daughters whose production of milk would be above the average, but that the relation is not a particularly close one. Similarly, there is but small relation between the conformation of the dam and the production of the daughter. Here again weight of the dam is the most important element of conformation in indicating what the probable production of the daughter will be. The other body measurements show practically no relation to the daughter's production.

A.D.B.S

Cows Progeny; Are High Records Harmful to a.

L. COPELAND. (1932). *Jersey Bull.*, Vol. 51, pp. 223-41.

It is the belief of some breeders that a high record of milk production not only ruins the majority of the dairy cows completing such records but also impairs their transmitting abilities, with the result that their daughters and sons born after they have completed a high record are definitely inferior to those which were born before the high record was made.

Mr. Copeland has studied this question with the material at his disposal in the Offices of the American Jersey Breed. He selected 113 medal of merit Jersey bulls whose dams have completed a record of over 600 lbs. of fat. Fifty-seven of these were born after their dams had completed the record, while fifty-six were born before they had finished a record higher than 600 lbs.

Similarly as regards the daughters, the basal line for their dams' production was taken as 700 gallons. For these it was found that the average production of their daughters born before the dam had completed this record was 651 lbs. of butterfat as compared to an average production of the daughters born after the dam had completed her

record of 652 lbs. This and other data indicate strongly that the making of a high record has no influence whatsoever on a cow's transmitting ability. While " forced feeding " may be harmful to the cow herself, such harmful effects are not transmitted to the progeny. It seems unwarranted to draw any other conclusions from these data, and these conclusions are consistent with modern genetic knowledge.

As a supplement to the main investigation, a study was made of the fecundity or the reproducing ability of nearly 1,200 cows with records of over 700 lbs. of butterfat. Only those cows were studied which had made records of over 700 lbs. at under six years of age. Five per cent. of these cows had no registered progeny born after their records ended. In many cases the high producing cows had as many as six, seven, or eight progeny, while one cow had eleven calves born to her after completing her record.

On the whole the conclusion is that extreme production has not affected the fertility of the cows. At the same time over-stimulation for production certainly does result in barrenness. With good care and management a cow with the correct hereditary constitution can be expected to give a high yield of milk without impairing either her own fertility or the vigour or productivity of her progeny. A.D.B.S.

Early Breeding on Ewes; The Effect of.

D. J. Griswold. (1933). *Amer. Soc. An. Prod.*, pp. 181-3.

At the beginning of 1927, 244 range raised Hampshire Rambouillet ewe lambs that averaged 74 lbs. were delivered at the North Dakota Experiment Station at Fargo. Half of these—122 lambs—were placed in breeding pens to produce lambs in May, 1928, the other group was kept open till late in 1928, when both groups were bred to produce lambs in May, 1929. Both groups have been bred each autumn for May lambs, and they have again been placed in the breeding pens for the 1933 crop. Except when it was necessary to separate them for the first breeding and lambing season, the ewes have run together the whole time. They were fed liberally enough to produce good growth and development, but no attempt was made to force them. In September, 1927, they weighed 74 lbs. Of the 122 lambs in the breeding pens in 1927, 104 conceived and produced 105 lambs in 1928. This was a production of 86 per cent. on the basis of ewes in the breeding pens. The young mothers had a good supply of milk, but many lambs were weak and had to be hand fed. In spite of the best care that could be given, the mortality was high. Only seventy-eight lambs survived to October 3rd, when they were weaned at an average weight of 68 pounds. The following May both groups produced lambs. Amongst the first group which had already given birth to a crop of lambs, the average weight of their lambs at weaning was 1 lb. greater than the other group which had never previously given birth to lambs.

In 1930 the average weight of the lambs at weaning was one pound greater for the yearling-bred group in 1929; three pounds greater in 1930; two pounds greater in 1931 and five pounds greater in 1932.

The percentage of fat lambs at weaning also has been consistently in favour of the yearling-bred group. The figures are sixty-eight to sixty-two in 1929; sixty-four to fifty-eight in 1930; forty-six to forty-five in 1931, and eighteen to ten in 1932.

It is yet too early to know whether these lamb-bred ewes will outlive their usefulness sooner than those not bred until one year older. At the present time, when the ewes are five and one-half years old, no definite indication that such will be the case has been observed.

So far the mortality from all causes has been the same, 25 per cent. for each group. A.D.B.S.

Horses and Ponies; The "Pied" and "Splashed White" Patterns in.

V. KLEMOLA. (1933). *J. Hered.*, Vol. 24, No. 2, pp. 65-9.

The piebald or skewbald pattern of horses behaves as a simple dominant. That is to say, that a piebald horse can only be obtained when at least one of its parents is also piebald. Wall eye is rarely associated with the piebald character, and however little colour may be shown on a piebald animal, some colour is always to be found upon its head.

In the character to which the present writer refers, the pattern factor is very nearly the reverse to that of piebald, since it is the head which lacks colour. This marking has been termed "Splashed White," and is associated with Wall eye. This "Splashed White" is inherited in a recessive manner. A.D.B.S.

Inbreeding Berkshire Swine.

E. H. HUGHES. *J. Hered.* (1933), Vol. 24, pp. 199-203.

This paper refers to various inbreeding experiments which are being conducted for pigs in different parts of the United States, but particularly deals with the inbreeding work on Berkshire pigs conducted at the Californian Experiment Station. The average number of pigs farrowed in the inbred litters has been greater (9.8 pigs per litter) than the average for the Berkshire Herd (8.1). There has, however, been a slight but gradual decrease in the number of pigs farrowed in the inbred litters of recent years. The type of the pigs in the inbred litters has been similar, which shows that uniformity has been obtained. There have been no structural abnormalities found in any of the inbred pigs, nor any of the unusual colourations reported by other workers.

A.D.B.S.

Inbreeding in Cattle.

T. E. WOODWARD AND R. R. GRAVES (1933), *U.S. Dept. Agric. Tech. Bull.*, No. 339.

Deliberate experiments into the hereditary constitution of cattle are few and far between. They could indeed be almost numbered on the fingers of two hands. Those which have been brought to anything like a conclusion are even fewer. The present experiment designed to study the results of inbreeding in Guernseys and Holstein Friesians was commenced in 1912 at the United States' Dairy Experiment Station at Beltsville, Maryland. The originators asked themselves this question:—"Can a good dairy herd be bred up from an ordinary one by the use of only one good bull?"

In 1912 sixteen cows of mixed breeding were purchased. They were of only average production and showed traces of Shorthorn, Angus, and Jersey breeding. A Guernsey bull was purchased and mated to them; he was again mated to his own daughters out of these cows and then to his grand-daughters, and finally his sons and grand-sons were mated to the progeny.

A number of deformed calves resulted from this source of inbreeding. They were all of the type known as the "bull-dog calf," and the evidence available indicates that this harmful character was carried by the Guernsey bull, and the results closely agree with those obtained by Professor Crew at the Institute of Animal Genetics.

As regards the production of milk and butterfat, the yields of the first generation daughters (outbred) were about the same as their dams, but the butterfat yield was higher by some 20 lbs. The inbred granddaughters (which were also daughters) produced slightly less milk than their dams but gave considerably more butterfat. From this we can conclude that the bull employed did not possess inherent capacity of raising the total yield of milk, but that he had, to a minor degree, the hereditary constitution for higher butterfat than the cows to which he was originally mated.

In the year 1918 the authorities realised that the results of such an experiment would depend largely upon the individuality of the bull used. Accordingly they purchased a Friesian bull which they used on the same foundation cows as those used for the Guernsey bull.

Inbreeding did not adversely affect the readiness with which the cows conceived. From 1926-31, 89 highly inbred calves were born and there was no unusual occurrence of abnormality. In fact more pregnancies terminated normally than was the case in the outbred herd which was maintained at the same place at the same time and under the same conditions.

During the twenty years of this inbreeding experiment, only one deformed calf was born and this deformity was not the same as that found in the inbred Guernseys. At first the birthweight of the calves showed a tendency to rise from 82 lbs. with the first (outbred) generation (21 calves) to 108 lbs. (18 calves) with the inbred generation by a son of the original bull. Much the same holds good as regards the growth rate of the inbred animals, but as regards size of the cows at maturity there is a difference. As inbreeding has become more intense there has been a definite trend in the direction of heavier weight at maturity, and this has not been accompanied by any sign of a loss of vigour. Only one of the inbred cows has been a delicate feeder.

The foundation cows had a yield of 1,168 gallons. The first generation daughters (outbred) gave 1,555 gallons with an increase of 70 lbs. in butterfat yield. A subsequent generation has given 1,828 gallons with an increase on the yield of the foundation cows of nearly 100 lbs. of butterfat.

In this experiment a bull that proved to possess an inheritance for a high level of milk production has been mated to ordinary grade cows, and has brought about a big increase in production, especially in the first generation (outbred) daughters. Subsequent improvement through inbreeding was slow. The writers are of opinion that the hereditary constitution of a bull influences production more than the system of breeding. A.D.B.S

Pregnancy in Domestic Animals; The Biological Diagnosis of.

S. A. Adsell and L. L. Madsen. (1933). *Cornell Veterinarian*, Vol. 23, No. 1, pp. 59-63.

With certain animals diagnosis of pregnancy is becoming an established fact, and is being rapidly incorporated into both medical

and agricultural practice. At the Institute of Animal Genetics in Edinburgh, two pregnancy diagnosis stations have now been established for some time upon a commercial basis, relating to the human and to mares. In each case the degree of accuracy is about 98 per cent.

In the present paper the writers review the main methods employed in diagnosing pregnancy. The first is what is termed the "placental sign" and consists of a leakage of small cells (erythrocytes) from the foetus at an early stage of pregnancy. This leakage may be detected by microscopic examination. It was first noted in the rat and has also been found in some kinds of monkey. It would appear that it is also likely to be found both in the cat and in the dog. The writers have endeavoured to see whether this method could be applied to cattle, but have failed in their attempt.

The second method is now being used with great success in the human, and depends upon the presence of a hormonic or similar action from the gonad which stimulates the blood or the urine. This substance may be detected by its effects on the ovaries of the immature mouse or rat. Urine or blood serum containing this substance when injected into these animals over a period of four days, causes development of the ovary. This reaction was discovered by Drs. Zondek and Aschheim in 1931, and is the routine method now used at the Institute of Animal Genetics in Edinburgh. This mouse test, as it is commonly called, does not work with the blood or urine of the elephant, rat, mouse, rabbit, cow, or pig. In the mare there are certain other secretions which interfere with the full working of the reaction. Accordingly the Zondek-Aschheim method cannot always be considered to be reliable when applied to mares. The writers of the present paper were unable to apply this method successfully either to the cow or the goat.

The third method depends upon the detection of an increase in the content of oestrin in the urine during pregnancy. This method is of more universal use than any of the others, but it is not quite so reliable as to results from early pregnancy. It is on this principle that the equine pregnancy diagnosis station at the Institute of Animal Genetics is conducted with practically invariable success so long as the sample of urine is taken not less than sixty days after service.

The work of Dr. Turner and his colleagues at the Missouri Agricultural Experiment Station goes to show that it may be possible to apply this test successfully to cattle, but the reliability of it may be called in question before the one-hundredth day, though it is stated that with care reliable results may be obtained from seventy days onward, but no thorough investigation appears to have been made of the use of this test. In the case of valuable pedigree stock it is important to know at the earliest date if an animal is pregnant. These tests are also of assistance in distinguishing between pregnancy and some forms of sterility. The fact that the reactions require experimental animals for their carrying out demands the establishment of a central diagnosis station such as has already been set up in Edinburgh, where either a veterinary surgeon or a practical farmer may have a diagnosis made.

A.D.B.S.

Records of Daughters of fifty-one Ayrshire Sires; Analysis of.
M. H. FOHRMAN and R. R. GRAVES. (1933). *U.S. Dept. Agric. Tech. Bull.*, No. 349.

This Bulletin is an impressive study of some 600 pedigree Ayrshire cows which were entered in the American Advanced Registry Records. All yields were corrected for age. The cows were the daughters of fifty-one Ayrshire bulls. The correlation of the yields of the daughters to that of their dams is + 0.262. This is lower than the figure obtained by the majority of other studies, and may perhaps be explained by the fact that the animals dealt with are not a random sample, since they have been selected on the basis of their sires.

Fifty-four dams had records exceeding 1,500 gallons, but in only five cases did their daughters beat their mother's record. Sixty-five dams gave less than 900 gallons, and only five of their daughters gave less than their dams. Accordingly the writers conclude that selection from the female side alone holds small promise for improvement.

The 611 daughters produced on an average 16 gallons more milk than did their dams. This shows a definite improvement in one generation. Mated to the dams which had produced over the average, these bulls depressed the yields, leaving the daughters worse than their dams by an average of 153 gallons. But mated to dams whose production was below the average the bulls increased the yields of their daughters by 181 gallons. Not one of the bulls was able to get daughters all of which were better than their dams, but three sired daughters, every one of which was a poorer producer than her mother.

Dealing with the question of the yield of the dam of a bull as an indication of the worth of that bull, the figures furnish clear evidence that the milk record of the dam of a sire does give some indication of the transmitting ability of that sire.

The second part of the paper is concerned with the inheritance of butterfat percentage. The dams average 3.97 per cent., while their daughters average 4.07, an increase of 0.1 per cent. The coefficient of correlation between dam and daughter was found to be + .257. The group of dams with a butterfat test of over 4.14 per cent. had the majority of their daughters giving a higher percentage than they themselves. There are also figures for the sires.

They conclude that, when due allowance is made for the effects of a fluctuating environment, the Mendelian Laws of Inheritance are adequate to explain the breeding results surveyed. There is no evidence for the assumption of sex-linkage, but there is no deliberate attempt made to examine this point. In agreement with other workers they find that total yield and butterfat are independent in their inheritance.

" Evaluating the transmitting ability of a proven sire requires a complete analysis of the performance of all his daughters, due consideration being given to the environmental influences. This necessitates a study of the herd in which the sire was proved. Correction factors designed to equalize these environmental influences are of questionable value, as there are no descriptive terms that will adequately define the variable conditions under which cows are tested. The certainty of success in breeding for uniformly high production is a sufficient incentive to cause the foresighted breeder to train himself to study and analyze performance records in order properly to select a

proved sire. A generation ago much effort was applied to pedigree analysis, and the same amount of effort devoted to mastering the intricacies of record analysis and proper interpretation will equip a breeder properly to select sires for his herd.

" The authors are of the opinion that no so-called bull index in existence to-day is so formulated as to afford a guide to constructive breeding procedure. At best, the bull index gives only a relative assay of the value of an animal as a sire. In a group of poor sires the one with the best index would still fail as a sire of daughters of high-milk production." A.D.B.S.

Uber die Erblichkeit der Fruchtbarkeit bei Hengsten. (Inheritance of **fertility in the stallion).**

Zuchtungskunde 7, pp. 58-62.

Microscopic examination of the sperm of a stallion may determine his fertility which may also be assessed by the percentage of mares which settle in foal to him. Dr. Kisslowsky has studied the stallions in East Friesland and has judged their fertility by the percentage of foals produced. On an average, 136 mares are successfully mated to each stallion in the year. One stallion had during a period of twelve years covered an average of 218 mares per year and gave the relatively high fertilisation figure of 66%.

The fertility of 63 stallions was found to be 57.7%. The sires of these stallions gave a figure of 61% of mares settled. The lowest figure for the sires was 49% while for the sons it was 25%. It was clear, therefore, that the sires had been subjected to selection which had eliminated variability and the poorest of them. A significant correlation was found between the fertility of the sire and his sons. A.D.B.S.

Wool Characters in " Half-Bred " Sheep.

J. E. Nicholls. *J. Agric. Sc.*, Vol. 28, pp. 473-84.

The " half-bred," the product of the Border Leicester ram and the Cheviot ewe, is an important contributor to the fat stock industry by reason of the sale of wether lambs for feeding in lowland areas, and the use of " half-bred " ewes with Down rams for producing cross-bred fat lambs.

In many flocks in the Border districts a second generation of the cross is raised by inter-mating half-bred rams and ewes. Some time ago the writer examined the claims frequently made that the " half-bred breeds true." In a previous paper he has discussed the variation and segregation which occurred in the first and second generation flocks. In noting the real evidence of segregation in the second generation the writer then employed only the obvious external differences of the fleece.

In this paper the figures are given of detailed analyses of a series of wool samples taken from selected sheep. The wool studied represents approximately twelve months' growth in all the sheep, though the animals were of different ages. For comparison, data from a number of similar samples from Border Leicester ewes and from a ram breeding flock were also included. The individuals for sampling were selected with the aid of the shepherds except in the case of the rams, where all those used were sampled. The parental types of wool did not overlap. The wool of the Border Leicesters was greater in length than that of

the Cheviots. The Border Leicesters studied were more uniform than the Cheviots, while the latter were more regular in fibre length.

As regards the first hybrid generation, the fibre lengths were for the most part intermediate between the parental types. The range of fineness was, however, greater than that of the Border Leicester ewes, but not so wide as that of the parental Cheviot samples.

Among the 88 ewes of the second generation of "half-bred" × "half-bred" the analyses show a wider range of mean fibre lengths, also the range of fineness was greater, and the range of mean fibre volume overlapped both the Border Leicester and the Cheviot shoulder series.

The writer concludes that evidence of blending inheritance is not manifest in the results, which supports the interpretation of multiple factors as responsible for the expression of the wool characters of length and fineness. A.D.B.S.

SOILS AND MANURES.

Abstractor:

RICE WILLIAMS, M.Sc., University College, Bangor.

Aqueous Solution of Ammonia as a Nitrogenous Fertiliser; Experiments on the use of.

S. DOLDI. *Ann. Tec. Agr.* (1933), 6, No. 2, 146-61.

Under the conditions prevailing where these experiments were carried out, aqueous ammonia solution was found to be a cheaper source of nitrogen and, when applied to neutral soils in pot tests, it gave dry matter yields superior to those obtained by treatment with either ammonium sulphate or sodium nitrate, but the nitrogen contents of the plants was the same with each of the three sources of nitrogen. On acid soils the yields of dry matter were less with aqueous ammonia than with the other two fertilisers, but the nitrogen content of the plants given aqueous ammonia was twice as much as those fertilised with ammonium sulphate or sodium nitrate. Of the three fertilisers, only ammonium sulphate had an effect on the reaction of a soil bearing vegetation. R.W.

The Calcium-Magnesium Ratio in Soils and its Relation to Crop Growth.

FRANK MESER. *J. Amer. Soc. Agron* (1933), 25, 6, 365-77.

Cylinder experiments were carried out on various soils treated with lime and magnesite. No correlation was found between the calcium-magnesium ratio, based on the total or the replaceable calcium and magnesium, and crop yields. The significant factor in determining yields was the amount of active calcium in the soils. The beneficial effect of adding lime to a soil was not due to an alteration of the calcium-magnesium ratio, but to an increase of the replaceable calcium content of the soil. R.W.

Chlorine-free Potash Fertilisers on Potatoes; Effect of.

T. ELLÉ. *Jahresber. Staatl. Vers. Mostad* (1930), 48 (1931).

The effect of potash salts on the growth of potatoes was investigated. Potash fertilisers containing chlorine reduced the starch in potatoes but

increased the yields. Chlorine-free sulphate of potash and nitrate of potash increased the yields very little, but did not reduce the starch content. R.W.

Fertilisation of Orchards. A Comparison of Nitrate of Soda and Sulphate of Ammonia.

H. E. Knowlton and M. B. Hoffman. *West Va. Agr. Expt. Sta. Bull.* (1932), 252, 2-12.

Field experiments on the use of nitrogenous fertilisers with apple trees showed a marked superiority of nitrate of soda over sulphate of ammonia. After five years the plots receiving sulphate of ammonia had a considerably higher lime requirement than those treated with nitrate of soda. The sulphate of ammonia had to be applied at least two weeks before the bloom. R.W.

Hydrated Lime, Limestone, and Dolomite of two degrees of fineness with Supplements of fine Clover Hay, as measured by Lysimeter Leachings; The Availability of

W. H. McIntyre, K. B. Sanders and W. M. Shaw. *J. Amer. Soc. Agron.* (1933), 25, 4, 285-97.

Four years' experiments are reported upon from the Tennessee Experiment Station. It was found that for a soil of good fixing capacity, even without marked acidity, 100-200 mesh fineness of either limestone or dolomite was as effective as the equivalent of hydrated lime when evaluated by enhanced nitrification and sulphate formation, soluble calcium plus magnesium and repressive effects upon potassium solubility. The same was found to hold for the 40-50 mesh limestone, but the 40-50 mesh dolomite was not so readily available during the first year. It is suggested that for heavy acid soils the 40-50 mesh material would be quite satisfactory, especially if an appreciable period is allowed between incorporation and seeding. The addition of green manure did not appreciably increase the loss of calcium plus magnesium supplied by the liming materials. The dressings applied were equivalent to one ton of calcium oxide per acre, and during the four year period about one-quarter of the added liming materials were lost from the soil. It is recommended that ground limestone should be evaluated on the basis of the fraction that is of fineness less than 40 mesh. R.W.

Lime Requirement of the Soil Related to the Type of Manuring; Is the?

E. Ernest. *Landtmannen.* (1932), 15, 303.

It was found that response to lime was greatest on unmanured plots and those receiving farmyard manure and farmyard manure plus superphosphate. All other manures lowered the response to lime. Sodium nitrate reduced the response least and calcium cyanamide most. R.W.

Manurial Treatments on the Chemical Composition of Strawberries; The Effect of various.

L. D. M. Knight and T. Wallace. *J. Pom. and Hort. Sci.* (1932), 10, 147-80.

The following manurial treatments were given in the 1931 season:— Farmyard manure; farmyard manure and complete inorganic fertiliser; complete bulky organic fertiliser; complete inorganic fertiliser; an

organic manure containing nitrogen and phosphorus, but no potassium. The results show that potassium deficiency is an important factor, and that a definite correlation exists between applications of potassic fertilisers and the chemical composition of strawberries. R.W.

Organic Matter; Influence of—on Crop Yield and on Carbon-Nitrogen Ratio and Nitrate Formation in the soil.

A. W. BLAIR and A. L. PRINCE. *Soil Sci.* (1938), 35, 3, 209-19.

Cylinder experiments were carried out at the New Jersey Experiment Station on the effect of added organic matter in the form of finely cut rye straw in quantities varying from one to eight tons per acre. Complete fertilisers were added in most of the work. The yields of non-legume crops were frequently less on the straw-treated than on the check cylinder. This depression of yield did not occur when legumes were grown or when extra nitrogen in the form of nitrate soda was added. This injurious effect of the rye straw was found to be temporary in character and was not shown in the second year after application. The rye straw had little effect on the percentage nitrogen in the crop but showed a gradual increase in the carbon and nitrogen of the soil as the amount of organic matter was increased. Small dressings did not greatly influence the carbon nitrogen ratio of the soil, but with four to eight tons per acre a wider carbon-nitrogen ratio was found. Nitrate determinations made at intervals during the period of the experiments indicated that an abundance of organic matter may depress nitrate formation. R.W.

Phosphatic Fertilisers; The Availability of.

R. P. BARTHOLOMEW. *Arkansas Sta. Bull.* (1933), 289, 1-19.

The availability of phosphorus from different sources was estimated from dry matter yield and phosphorus absorption. Superphosphate phosphorus was found more readily absorbed than that of mono calcium phosphate. Limestone and soluble phosphates could apparently be added together to acid soils without serious loss of phosphate availability. Neutralisation with ammonia up to 6.3% did not decrease the availability of superphosphate phosphorus. The low availability of rock phosphates could be improved by addition of magnesium sulphate but not enough to justify recommendation of the mixture for the local conditions studied. It is suggested that the increase in the absorbability of calcium phosphates effected by soluble magnesium salts is probably the explanation for the greater absorption of phosphorus from superphosphate and ammoniated superphosphates than from monocalcium phosphate. R.W.

Rock Phosphate in Illinois soils when used liberally for twenty-five to thirty years and Influence of the Treatment on Available Potash and Total Nitrogen; The Availability and Downward Movement of.

A. V. THOR. *J. Amer. Soc. Agron.* (1933), 25, 10, 661-74.

A study was made of the availability and downward movement of phosphorus in the soils of three Illinois Corn belt farms, to which liberal amounts of rock phosphates had been applied during the last 25 to 30 years. In all cases rock phosphates had given satisfactory

results. The amounts of soluble phosphorus (in 0.002N. H_2SO_4) had been increased on all three farms. The downward movement of phosphorus was also evident. On the open textured soils there was an appreciable movement into the 8″-16″ and 16″-24″ depths. On the more compact soil there was a definite movement into the 14″-21″ depth. The main cause of the downward movement is believed to be mechanical by gravitional water, whilst the decay of the roots of the deep-rooted legumes, lucerne and sweet clover is regarded as a subsidiary factor. The use of rock phosphate and lime with the growing of legumes regularly in the rotation had apparently increased the amounts of available potash and total nitrogen in the surface soil of two of the farms. In the case of the other farm this relationship had been masked by the large amounts naturally present and the inherent irregularities of the soil. R.W.

Rye and Oat Straws; Influence of—upon the Growth and Yield of Certain Vegetables.

B. E. Gilbert and F. R. Pember. *Soil Sci.* (1933), 35, 2, 115-22.

Evidence is contributed from the Rhode Island Experimental Station showing the inhibitory effects of large quantities of poorly decomposed organic matter upon plant growth. The effect of rye and oat straws of different compositions and stage of decomposition and at various rates of application on the growth of lettuce, celery, beets, carrots, onions, and spinach were tested in pot experiments. The results indicated that such resistant organic matter sources have doubtful value as substitutes for stable manure, and that although it may be possible to balance the inhibitory effect which accompanies the decomposition of low nitrogen straws by very large applications of nitrogen, these are of necessity so large as to be uneconomical. R.W.

Sodium Chlorate when used as an Herbicide; The Adsorption and Movement of.

W. E. Loomis, E. V. Smith, Russell Bisey, and L. E. Arnold. *J. Amer. Soc. Agron.* (1933), 24, 11, 724-39.

Sodium chlorate readily penetrates all the external surfaces of the plant with the exception of the unusually heavy cuticle or corky layers, and may be expected to gain entrance to the plant whether applied to the leaves, to herbaceous stems, to rhizomes, or to roots. When applied to the soil directly or reaching it in the drip and leachings from sprayed plants, sodium chlorate has persisted in the soil in an apparently unchanged form for 2½ years. It was particularly persistent when large quantities of the salt were allowed to accumulate in an unleached subsoil. From the soil solution it may be absorbed by the rhizomes and roots of plants and translocated to the tops so that both the tops and roots are killed by the toxin. The removal of sodium chlorate from the soil by leaching is possible, but large volumes of water are required and the evidence points to the decomposition of the salt as the principal cause of its disappearance. Decomposition is fairly rapid in moist soil at temperatures above 20°C but may be very slow in cool dry soil. It is suggested that this behaviour of the chlorate can be used to advantage in order to assure a continued action on persistent weeds and in avoiding excessive accumulation of chlorates in soils in which decomposition is normally slow. R.W.

Urea; Some Transformations of—and Their Resultant Effect on the Soil.

H. W. Jones. *Soil Sci.* (1932), 34, 4, 281-299.

Observations on the effect of soil moisture, of time, of temperature and of concentration of urea in the soil on the conversion of urea to ammonia and nitrates were made.

The rate of ammonia accumulation from urea decreased with increase in soil moisture in the early period of incubation, but when nitrification began the quantity of ammonia accumulated from urea decreased with an increase of moisture up to 13.95% of dry soil. At 15.85% and 17.95% moisture, the ammonia accumulation again increased, but at 20.55% moisture which gave an anaerobic condition of the soil very little ammonia accumulated from the urea. The conversion of ammonia to nitrate took place very slowly in comparison with the rate of conversion from urea to ammonia. Doubling the concentration of the urea in the soil produced a slightly higher concentration of nitrate nitrogen, but the percentage of urea nitrogen converted to nitrate was less at the higher concentration of urea. Over the average daily temperature range, 10°C to 30°C, the production of nitrates from urea appeared to vary directly with temperature. R.W.

AGRICULTURAL BOOKS, 1933.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of agriculture published during the year 1933, together with a few omitted from the list for 1932. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, *third edition*, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

ASTOR, W., *2nd Viscount Astor, and* MURRAY, K. A. H. The Planning of agriculture. Oxford: Univ. Press, 1933 pp. xvi, [ii], 186 ... ... 6s. 0d.

AUCHTER, E. C., *and* KNAPP, H. B. Orchard and small fruit culture . . . *2nd ed.* New York : Wiley, 1932. pp. xx, 584. ill., bibl. ... ... £1 11s. 0d.

BRITISH GOVERNMENT PUBLICATIONS : *War Office, Veterinary Department.* Animal management 1933. London : H.M.S.O., 1933. pp. 380. pls., ill., diags. ... ... 3s. 6d.

BURR, S., *and* TURNER, D. M. British economic grasses : their identification by the leaf anatomy. London : Edward Arnold, 1933. pp. 94. ill. ... 10s. 6d.

CAMPBELL, P. C. American agricultural policy. London : King, 1933. pp. xviii, 304 ... ... 10s. 6d.

EDMONDS, J. LL., *and others.* Producing farm livestock . . . New York : Wiley, 1932. pp. xiv, 440. front., ill., bibl. ... ... 15s. 6d.

FAULKNER, O. T., *and* MACKIE, J. R. West African agriculture. Cambridge : Univ. Press, 1933. pp. viii, 168. front. ... ... 8s. 6d.

FREAM, W. Elements of agriculture . . . by the late W. Fream. *12th ed.* . . . edit. by Sir R. H. Biffen. London : John Murray, 1932. pp. viii, 720. pls., ill., bibl. ... ... 10s. 6d.

GETMAN, A. K., *and* CHAPMAN, P. W. The Young man in farming. New York : Wiley, 1933. pp. x, 216. diags. ... ... 10s. 6d.

GOOD, R., Plants and human economics. Cambridge : University Press, 1933. pp. xii, 202. maps, bibl. ... ... 5s. 0d.

GRIEVE, M. Culinary herbs and condiments. London: Heinemann, 1933. pp. vi, 210 ... ... 5s. 0d.

HARLER, C. R. The Culture and marketing of tea. London: Humphrey Milford, 1933. pp. xii, 390. front., pls., maps. ... ... 12s. 6d.

HEALD, F. D. Manual of plant diseases . . . *2nd ed.* New York: McGraw Hill Book Co. Inc., 1933. pp. xii, 954. ill., diags., bibl. ... ... 45s. 0d.

ISRAELSON, O. W. Irrigation principles and practices. [Agriculture]. New York: Wiley, 1932. pp. xiv, 422. front., ill., maps., bibl. *Wiley Agricultural Engineering Series* ... ... £1 11s. 0d.

HOARE, E. W. Hoare's veterinary materia medica and therapeutics . . . *5th ed.* edit. and rev. by J. R. Greig. London: Baillière, Tindall, & Cox, 1933. pp. viii, 510 ... ... 21s. 0d.

HUNTER, H. *and* LEAKE, H. M. Recent advances in agricultural plant breeding. London: Churchill, 1933. pp. x, 362. pls., bibl. ... ... 15s. 0d.

INGLE, H. A Manual of agricultural chemistry . . . *5th ed. rev.* London: Benn, 1933. pp. x, 448 ... 15s. 0d.

JEKYLL, G. Wall and water gardens . . . *8th ed. rev.* London: Country Life Ltd., 1933. pp. xvi, 246. front., ill., diags. ... ... 15s. 0d.

MACSELF, A. J. French intensive gardening. London: Collingridge, [1933] pp. 128. frônt., pls., ill. 7s. 6d.

MOORE, R. R. H. Pruning in summer: an unorthdox method of growing apples and pears for amateurs . . . London: Burrow, 1933. pp. 28. ill., diags. ... ... 2s. 0d.

NORRIS, T. C. Practical sheep farming. London: Allen & Unwin, 1933. pp. 280. front., pls., diags. 10s. 6d.

OSBORN, A. Shrubs and trees for the garden. London: Ward Lock, 1933. pp. 576. col. front., pls. £1 1s. 0d.

OXFORD: *University Agricultural Economics Research Institute.* Progress in English farming systems. VII. The Flexibility of farming, by A. Bridges, assisted by E. L. Jones. Oxford: Clarendon Press, 1933. pp. 40. pls. ... ... 1s. 6d.

RAWLINS, T. E. Phytopathological and botanical research methods. New York: Wiley, 1933. pp. x, 156, bibl. $2 50

REDGROVE, H. S. Spices and condiments. London: Pitman, 1933. pp. xviii, 362. front., ill., diags., bibl. ... ... 15s. 0d.

ROBINSON, W. The English flower garden and home grounds . . . *15th ed.* London: John Murray, 1933. pp. xx, 720. ill. ... ... 18s. 0d.

ROHDE, E. S. The Story of the garden . . . London: The Medici Society, 1932. pp. xii, 326. col. front., col. pls., ill., bibl. ... ... 16s. 0d.

ROYAL INSTITUTE OF INTERNATIONAL AFFAIRS. World agriculture; an international survey. Oxford: University Press, 1932. pp. viii, 314 ... 12s. 6d.

RUSSELL, *Sir* E. J. The farm and the nation. London: Allen & Unwin, 1933. pp. 240 ... ... 7s. 6d.

SINGLETON, E. The Shakespeare garden. London: Cecil Palmer [1932] pp. xxvi, 366. front., pls., bibl. 12s. 6d.

SMITH, A. D. BUCHANAN-, *and* ROBISON, O. J. The Genetics of cattle: Reprint from '*Bibliographia*' *Genetica* X. 1933. pp. 104. bibl.

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